

AD624413

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.	DATE
			<i>Model 84454</i>	

REPORT

NO. XAR-A-45

DATE Aug. 26, 1963

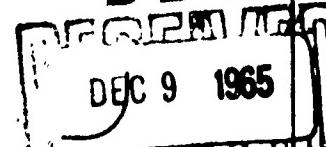
EXPERIMENTAL STUDY OF
HIGH SPEED HYDROFOILS

VOLUME II

PART IV

CODE 26512

DDC



H. R. Wright Jr.
H. R. Wright

PREPARED BY:

G. J. Wenzel
G. J. Wenzel

APPROVED BY:

J. Hubert
J. Hubert

T. B. Street
CHECKED BY:

REVISIONS

DATE	REV. BY	REVISIONS & ADDED PAGES	REMARKS

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SUMMARY

This test program was conducted to measure the hydrodynamic characteristics of a series of transcavitating, and supercavitating hydrofoil models with various planforms and sections to provide a design procedure to predict hydrodynamic characteristics for this type hydrofoil. Twenty hydrofoil models were tested in the Grumman Whirling tank at three depths and at a sufficient number of speeds and angles of attack to fully define their hydrodynamic characteristics. Lift, drag, pitching moment, and strut base pressure were measured for all models, and cavity pressure and foil pressure were measured for the supercavitating models.

Classic supercavitating hydrofoil theory is shown to predict test results with an accuracy adequate for design if a modified value for the cross-flow lift coefficient is accepted.

INTRODUCTION

The work under this contract consisted of testing twenty supercavitating and transcavitating hydrofoil models in the Grumman Whirling Tank at three depths and at a sufficient number of speeds and angles of attack to fully define their hydrodynamic characteristics. The models include aspect ratios of 1.0 to 5.0, sweep angles of 0 to 56.3°, taper ratios of 0 to 1.0, design lift coefficients of 0 to .350, and were tested at cavitation numbers of .029 to .145. All models were mounted on a single 15% thick, blunt base parabolic strut except the aspect ratio = 5 model which was mounted on a twin strut combination.

Lift, drag, pitching moment, and strut base pressure were measured for all models, and cavity pressure and foil base pressure were measured for the supercavitating models. The foil cavity pressure was measured by means of a static pressure tap centrally located on the upper surface of one semi-span.

Analysis of the test results was limited to the supercavitating lift and drag data; the transition from fully wetted to supercavitating did not cover significant angle of attack range on any foil tested. Transition from wetted to cavitated flow on these foils was characteristically accompanied by a very high frequency vibration audible as a loud screech. A study of this "singing" phenomenon did not conclusively identify the source but gave some indication that it was associated with a stall flutter type of instability.

The work of this contract has been submitted in three volumes. Volume I presents the measured results in tabular form, the correlation of results, the structural analysis, and an analysis of the "singing" phenomenon encountered during the tests. This volume presents the measured results in graphical form. Volume III summarizes the test results as a procedure for the prediction of the lift and drag for a supercavitating hydrofoil of arbitrary section and planform with a numerical example. Volume III is written as a complete summary report suited to wide distribution.

CONCLUSIONS

Classic supercavitating hydrofoil theory provides adequate correlation for these results if a modified value for the cross-flow lift coefficient is accepted. With the modified cross-flow lift coefficient, the correlation of the fifty-nine measured lift and drag curves with classic supercavitating hydrofoil theory may be summarized statistically as a prediction reliability (+ error indicates measurement higher than predicted):

	<u>Mean Error</u>	<u>Reliable Error</u>
Lift Coefficient	- .0002	± .012
Drag Coefficient	.0012	± .0028

DISCUSSION

The measured data is presented in graphical form in this section as plots of lift coefficient, drag coefficient, and pitching moment coefficient. The speeds specified are nominal. The actual speeds varied by about 5%, however, all data reduction was based upon the actual measured dynamic pressure.

The specified submergences are in mean geometric chords. The drag coefficients include strut drag. Moment coefficients are referenced to the quarter-chord of the mean geometric chord. The measured ventilated coefficients have not been corrected for cavity pressure and generally correspond to atmospheric cavity pressure.

LIS. C. CUR.Figures

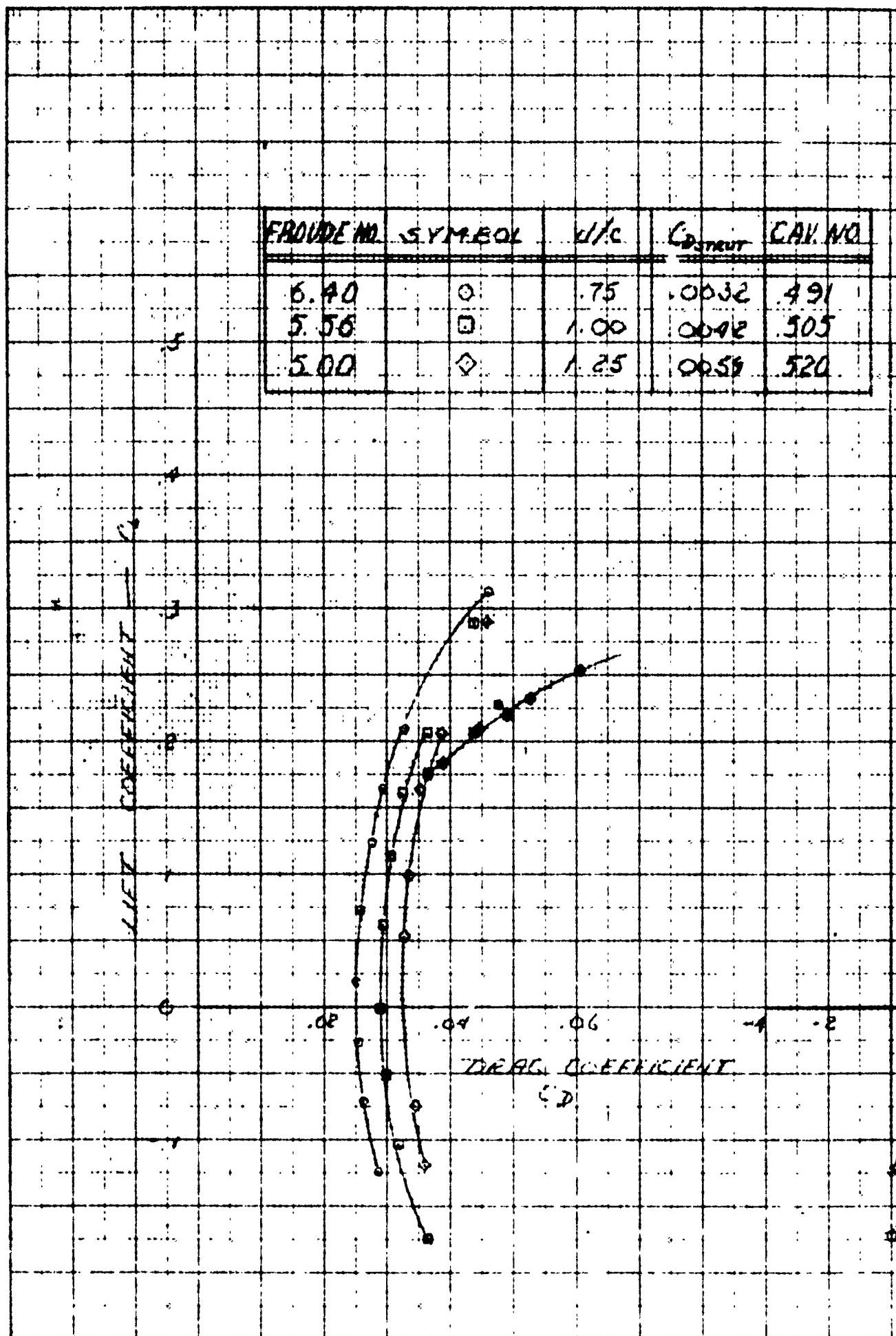
Foil No.	Speed Knots	Fig. No. & Page No.	Foil No.	Speed Knots	Fig. No. & Page No.
1	40	IV.1	7	40	IV.35
	45	IV.2		45	IV.30
	50	IV.3		50	IV.37
	60	IV.4		60	IV.38
	70	IV.5		70	IV.39
	80	IV.6			
2	40	IV.7	3	40	IV.40
	45	IV.8		45	IV.41
	50	IV.9		50	IV.42
	60	IV.10		60	IV.43
	70	IV.11		70	IV.44
3	40	IV.12	9	40	IV.46
	45	IV.13		45	IV.47
	50	IV.14		50	IV.48
	60	IV.15		60	IV.49
	70	IV.16		70	IV.50
	80	IV.17		80	IV.51
4	40	IV.18	10	40	IV.52
	45	IV.19		45	IV.53
	50	IV.20			
	60	IV.21		40	IV.54
	70	IV.22		45	IV.55
	80	IV.23		50	IV.56
5	40	IV.24	11	60	IV.57
	45	IV.25		70	IV.58
	50	IV.26		80	IV.59
	60	IV.27		40	IV.60
	70	IV.28		45	IV.61
	80	IV.29		50	IV.62
6	40	IV.30	12	60	IV.63
	45	IV.31		70	IV.64
	50	IV.32		80	IV.65
	60	IV.33			
	70	IV.34			

LIST OF FIGURES (Cont'd.)

Foil No.	Speed Knots	Fig. No. & Page No.	Foil No.	Speed Knots	Fig. No. & Page No.
13	40	IV.66	17	40	IV.90
	45	IV.67		45	IV.91
	50	IV.68		50	IV.92
	60	IV.69		60	IV.93
	70	IV.70		70	IV.94
	80	IV.71		80	IV.95
				90	IV.96
14	40	IV.72		96	IV.97
	45	IV.73			
	50	IV.74	18	40	IV.98
	60	IV.75		50	IV.99
	70	IV.76		60	IV.100
	80	IV.77		70	IV.101
				80	IV.102
15	40	IV.78		90	IV.103
	45	IV.79		95	IV.104
	50	IV.80			
	60	IV.81	19	40	IV.105
	70	IV.82		50	IV.106
	80	IV.83		60	IV.107
				70	IV.108
16	40	IV.84		80	IV.109
	45	IV.85		90	IV.110
	50	IV.86		96	IV.111
	60	IV.87			
	70	IV.88	20	40	IV.112
	80	IV.89		50	IV.113
				60	IV.114
				70	IV.115
				80	IV.116
				90	IV.117
				95	IV.118

LIST OF GL. E. (Cont'd.)Flapped Foil Tests

<u>Foil No.</u>	<u>Speed Knots</u>	<u>d/c</u>	<u>Fig. No. & Page No.</u>
13	40	.75	IV.119
		1.00	IV.120
		1.25	IV.121
	45	.75	IV.122
		1.00	IV.123
		1.25	IV.124
	50	.75	IV.125
		1.00	IV.126
		1.25	IV.127
	60	.75	IV.128
		1.00	IV.129
		1.25	IV.130
	70	.75	IV.131
		1.00	IV.132
		1.25	IV.133
	80	.75	IV.134
		1.00	IV.135
		1.25	IV.136
14	40	1.00	IV.137
	45		IV.138
	50		IV.139
	60		IV.140
	70		IV.141
	80		IV.142
15	40	1.00	IV.143
	45		IV.144
	50		IV.145
	60		IV.146
	70		IV.147
	80		IV.148



PAGE III.1

WHIRLING TURBINE FLOW METER

NO 4s 2454

MODEL NO 7

40 KTS

MAC = 13.9 FT

NOTE

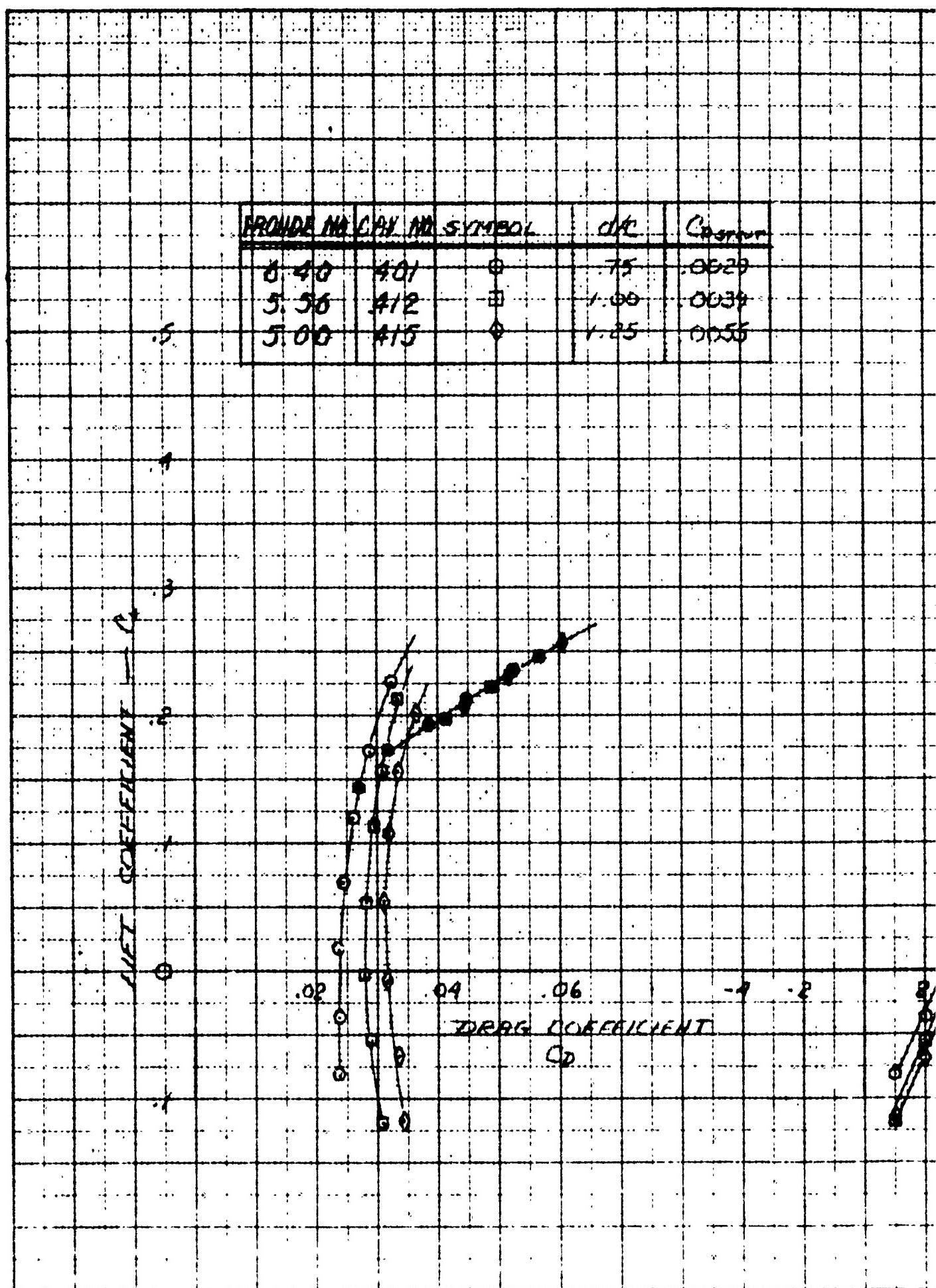
1. DARKENED SYMBOLS
INDICATE VENTED FLOW

2 15 1 6 5 10 12 - .03 - .04 - .05

ANGLE OF ATTACHMENT
- 24 DEGREES

PITCHING MOMENT
COEFFICIENT - CM³

CAM 7.15.66



PAGE IV 2

WIND TUNNEL TEST NO. 20

NO. 63 84450

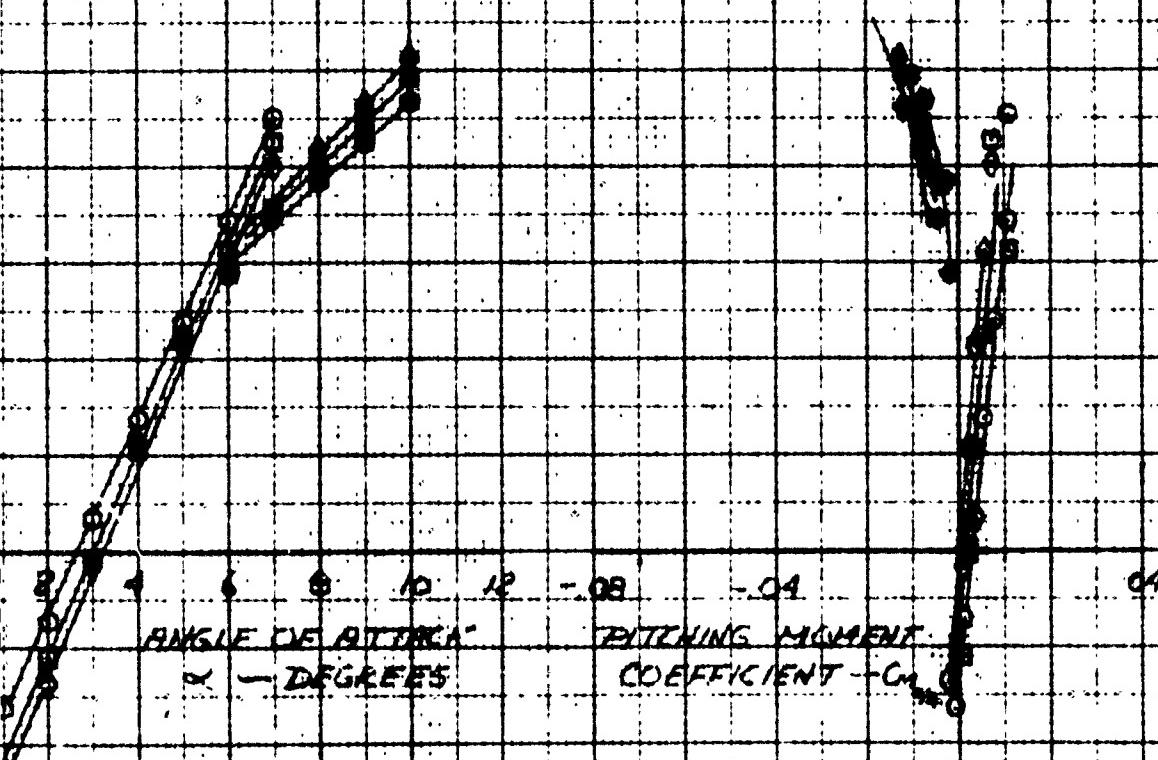
MODEL AR.1

12.75

MAC = 1.39 FT

NOTE:

1. DIAHEDRAL SYMBOLS INDICATE VENTED FLOW



CPH 7-146

PROUDL NO/OPN NO	SYMBOL	W/H	COUNT
540 320	o	.75	0028
550 335	□	1.00	0039
500 350	◊	1.25	0055

DRAWING CONVENTION

PAGE IV.3

WHIRLING TANK TEST NO. 2

No. 684454

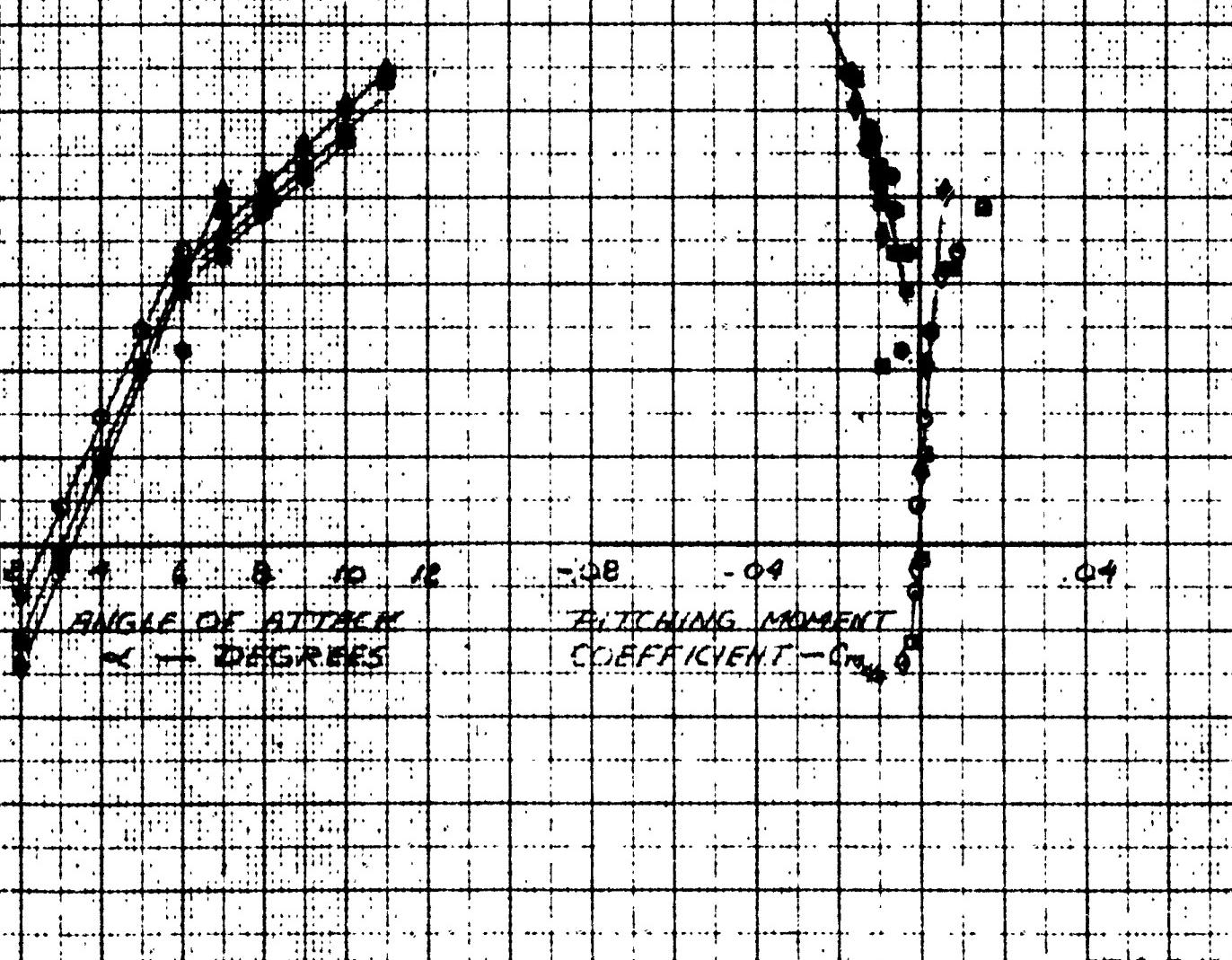
MODEL NO. 1

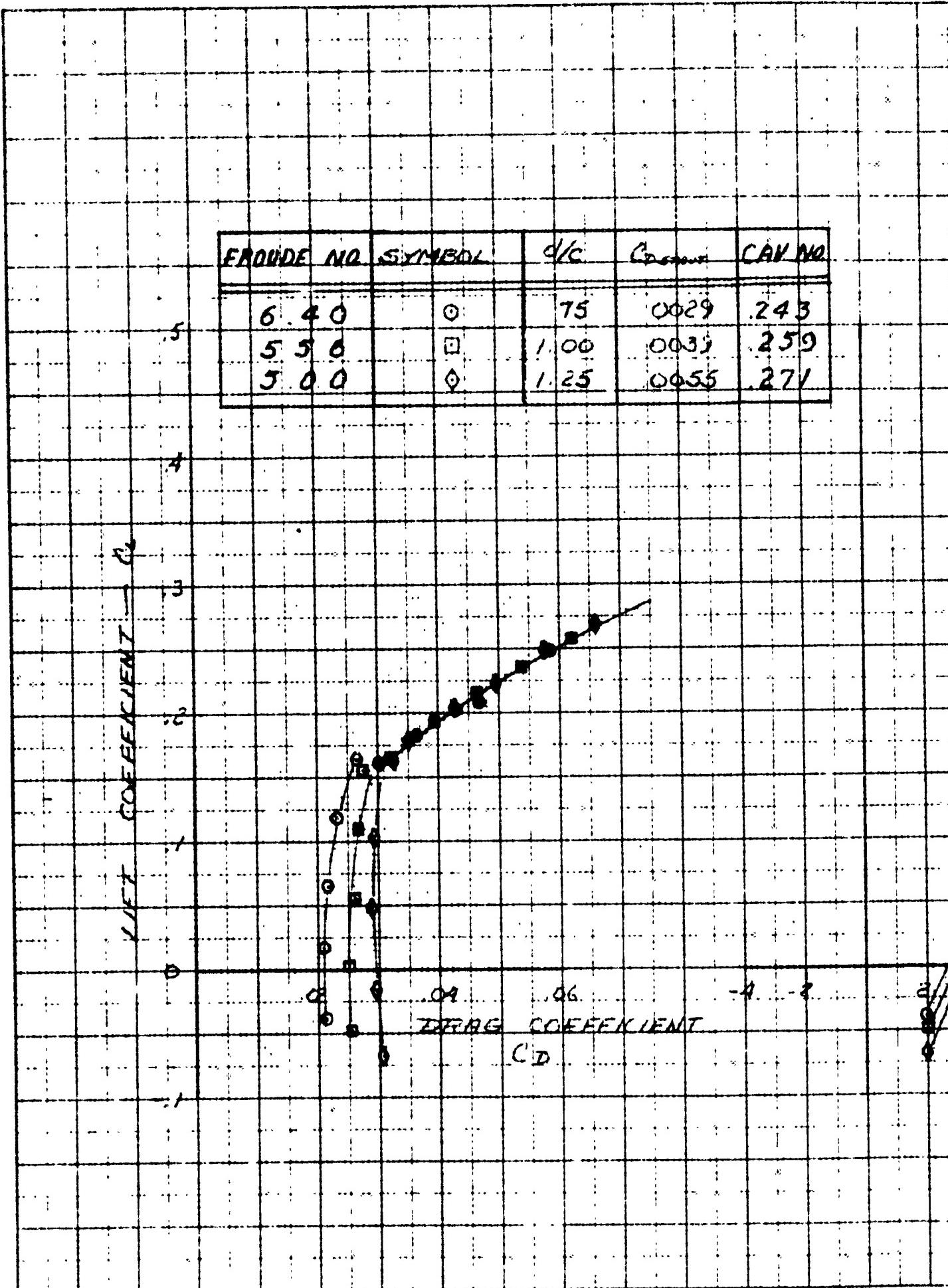
50 ATS

MAC = 139 FT

NOTE:

A DARKENED SYMBOL
INDICATE VENTED FLOW





PAGE IV.4

WHIRLING TANK TEST NO. 20

NC 65 84454

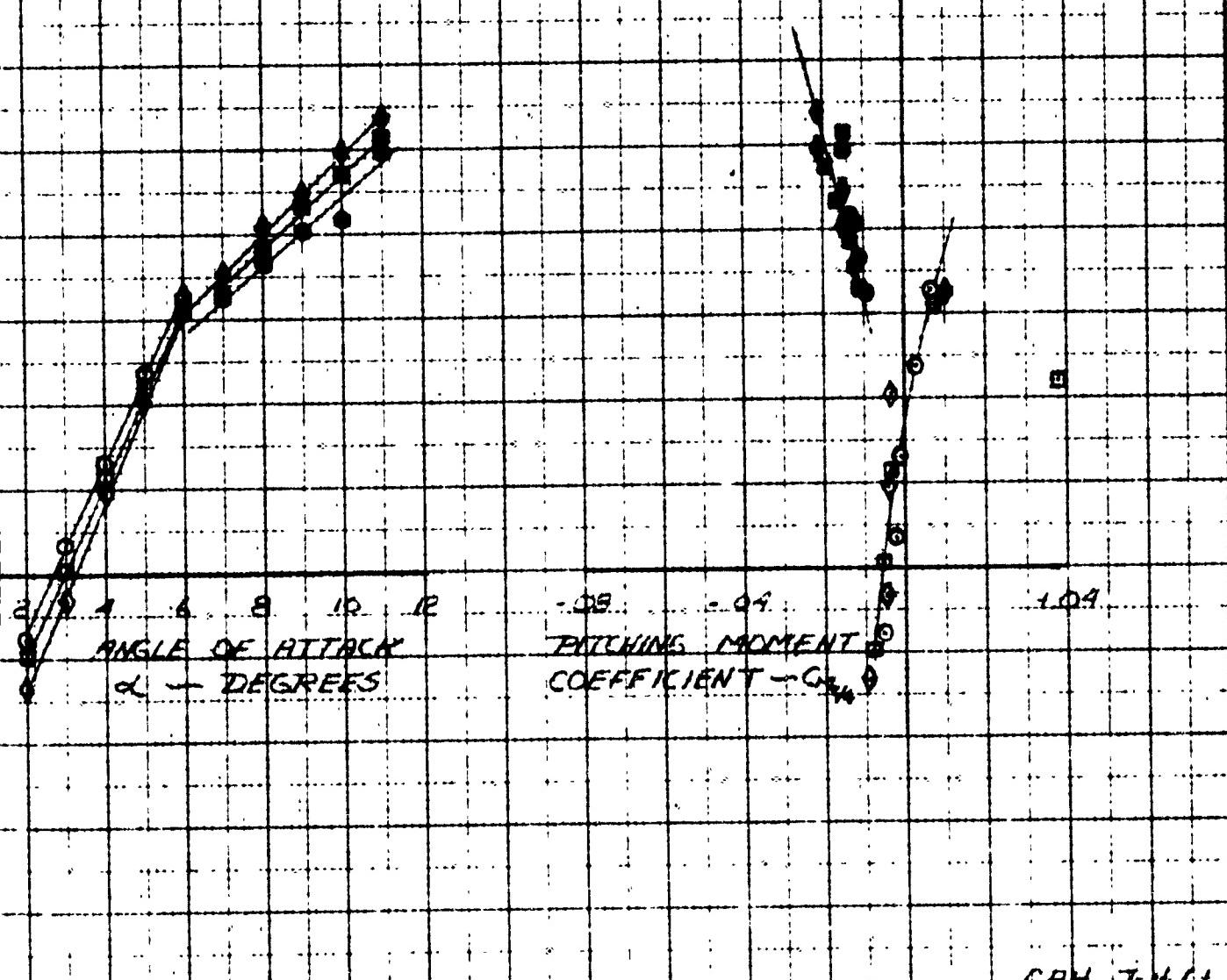
MODEL NO. 1

60 KTS.

MAC = 129 FT

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED ELBOW.



CPH 7-1-61

<u>FRONDE NO.</u>	<u>SYMBOL</u>	<u>d/c</u>	<u>CONSTANT CAV NO</u>
6-40	0	75	0030 .195
555	□	100	0041 .210
500	◊	125	0059 .224

LET CROSSHEAD —

TORQUE COEFFICIENT

C'D

PAGE IV .5

WHIRLING TANK TEST NO. 20

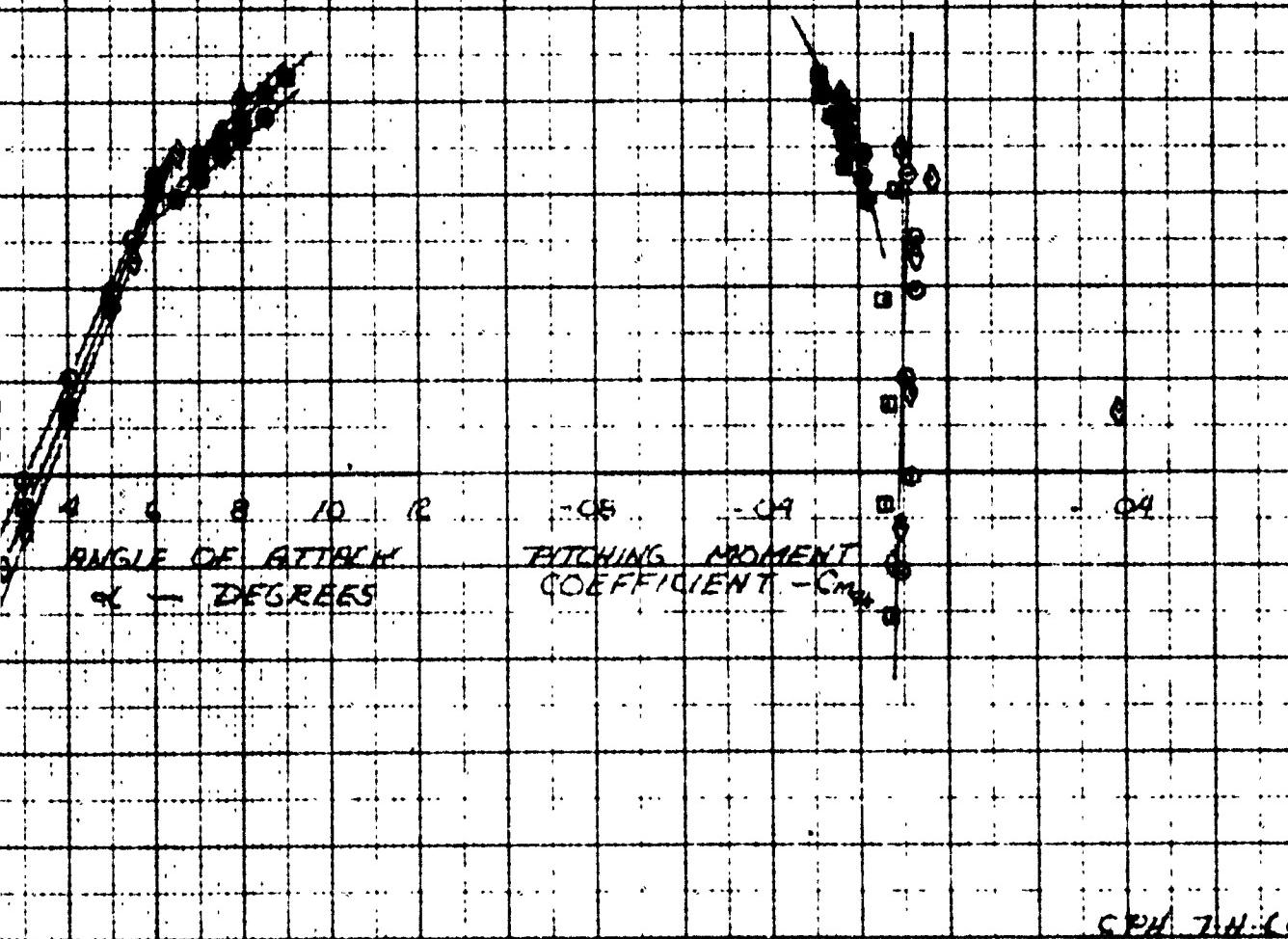
NO. 3 84954

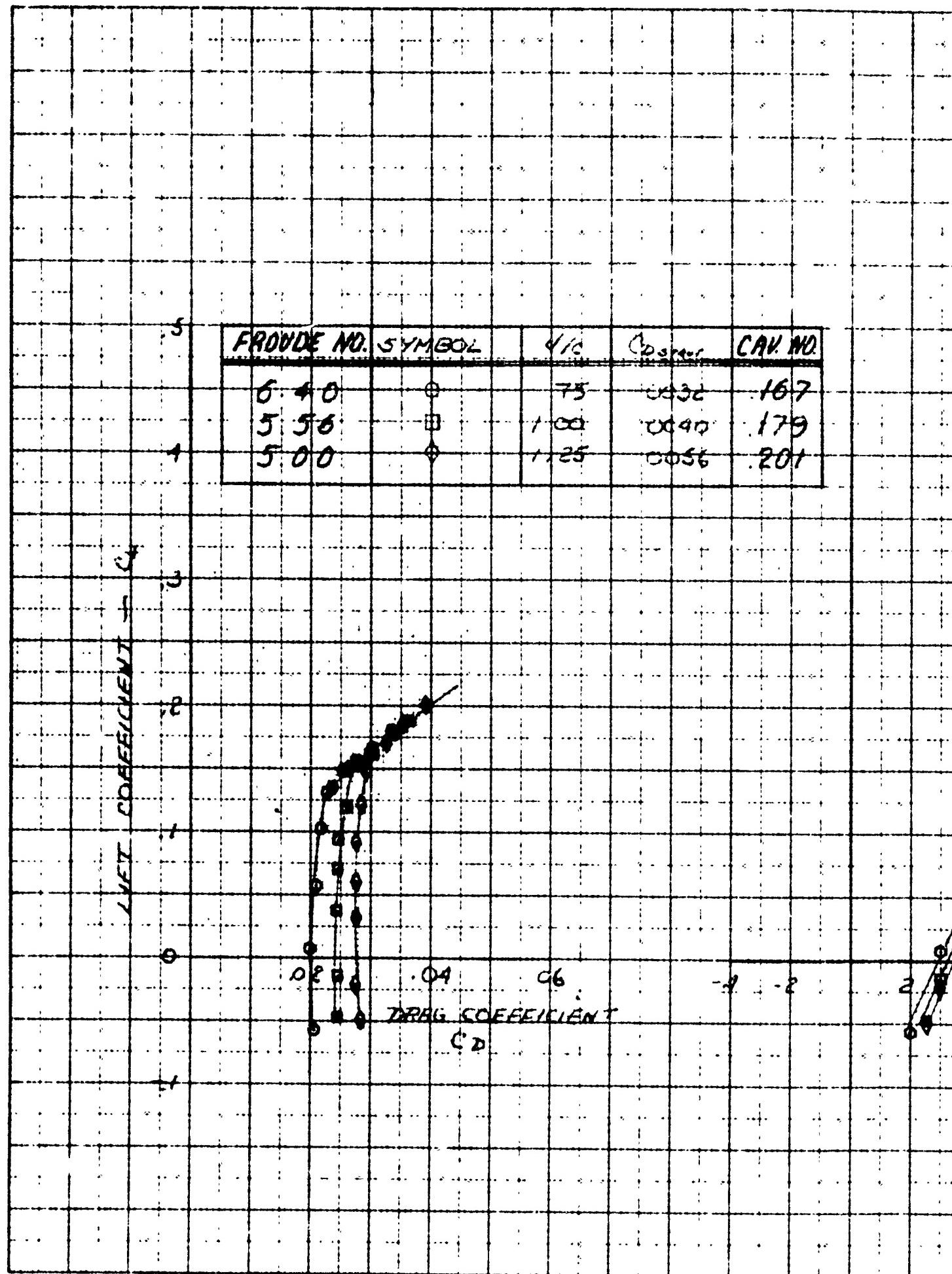
MODEL NO. 3

70 KTS

MAC = 137 FT

NOTE
DARKENED SYMBOLS
INDICATE VENTED FLOW





PAGE IV.6

WHIRLING TILT TEST N. 22

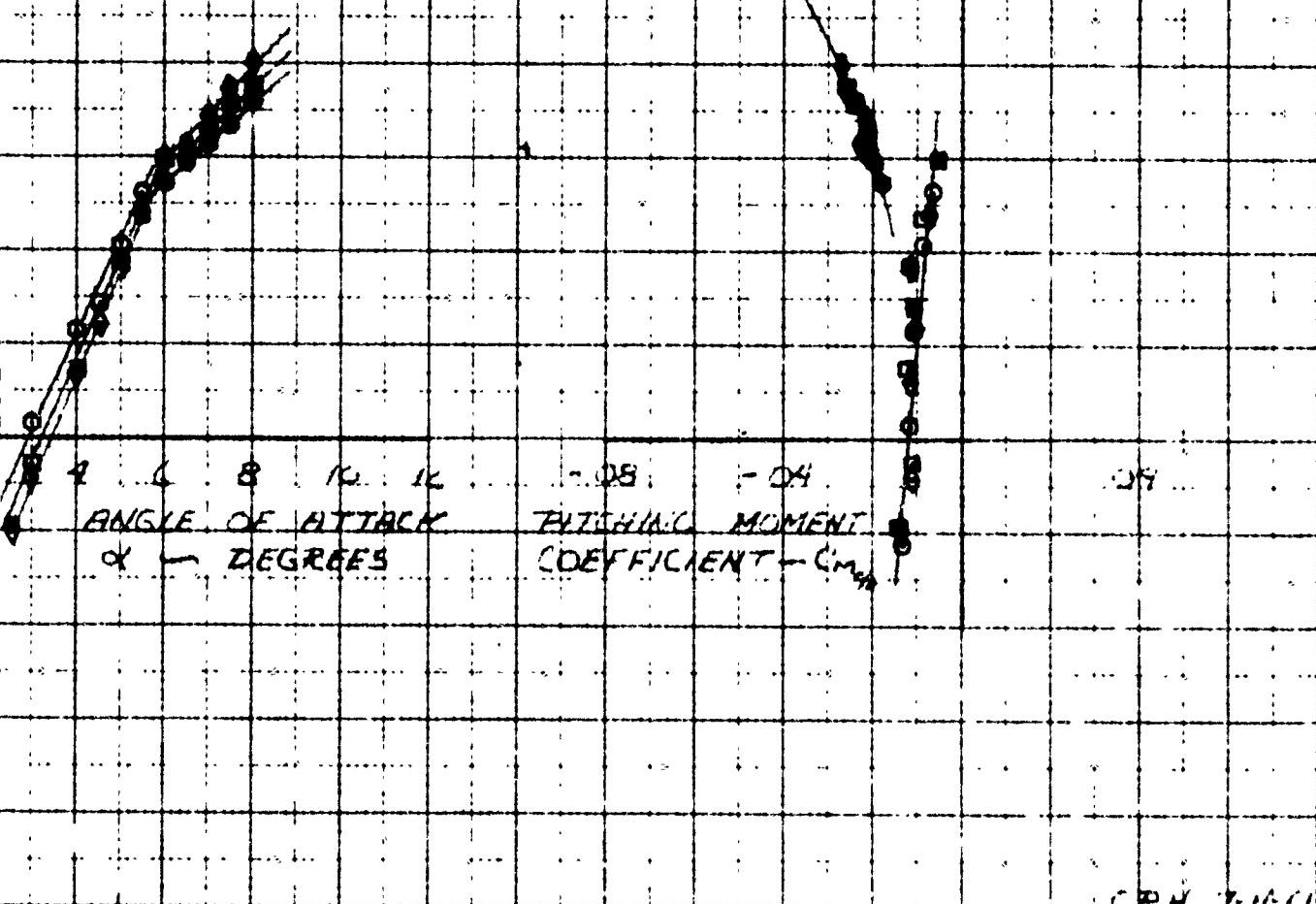
NOLs 634454

PICTURE N. 1

4.475

MAC = 1.7 FT

NOTE
DARKENED SYMBOLS
INDICATE VENTED FLOW



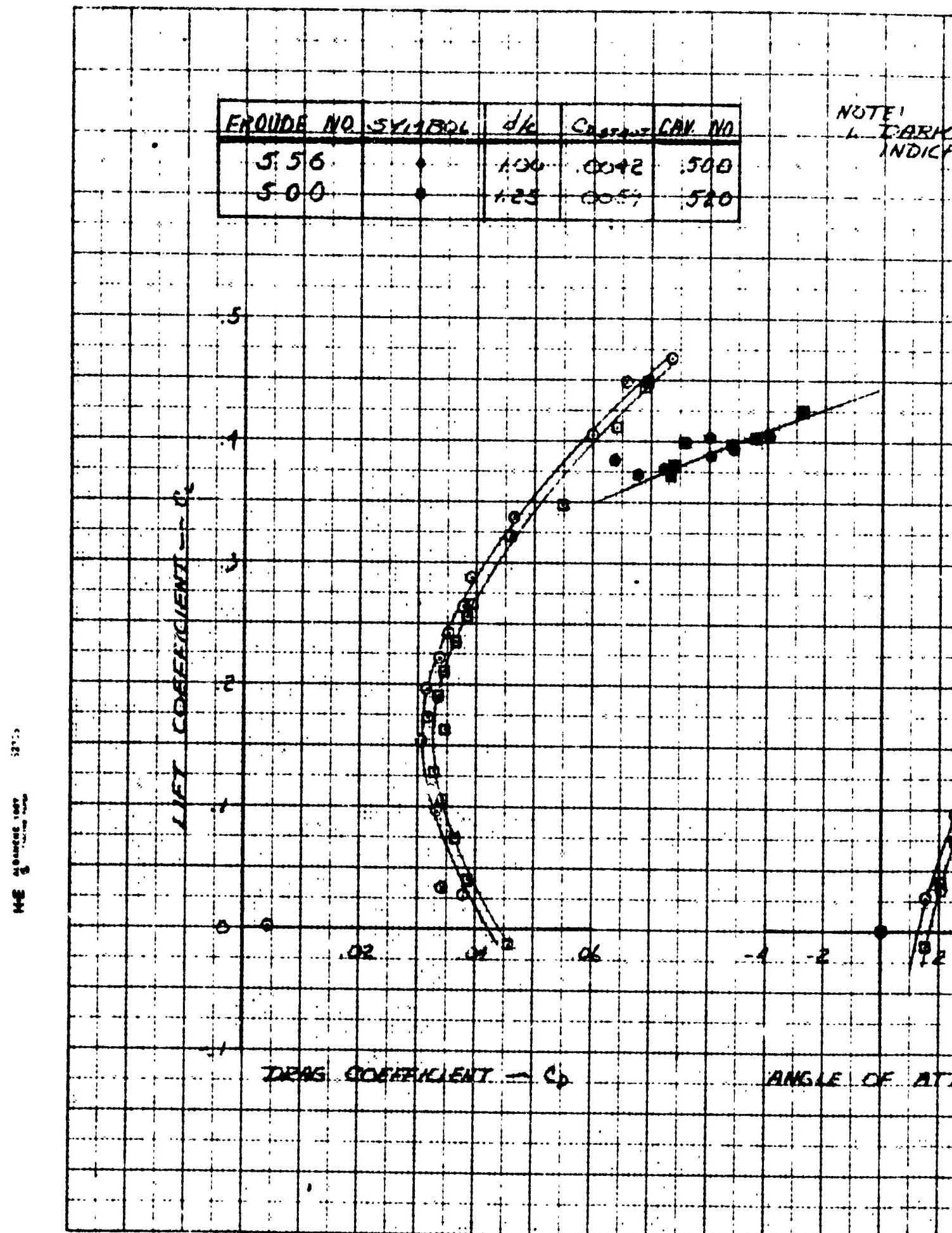


FIG. II 7

WHIRLING TANK TEST. NC 200

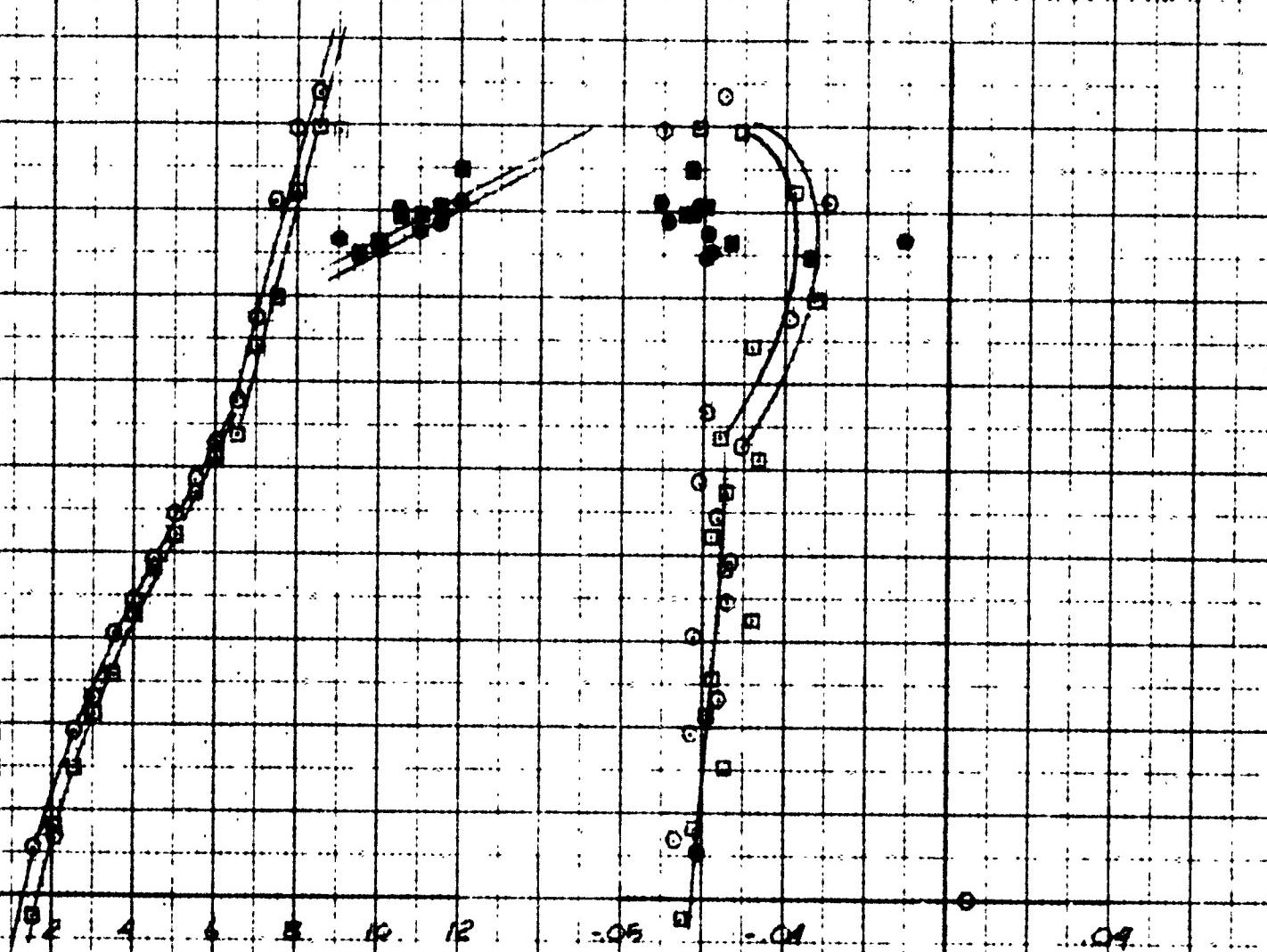
NO. S. 84454

MODEL. NC 2

40 KTS

MAC = 13.9 FT

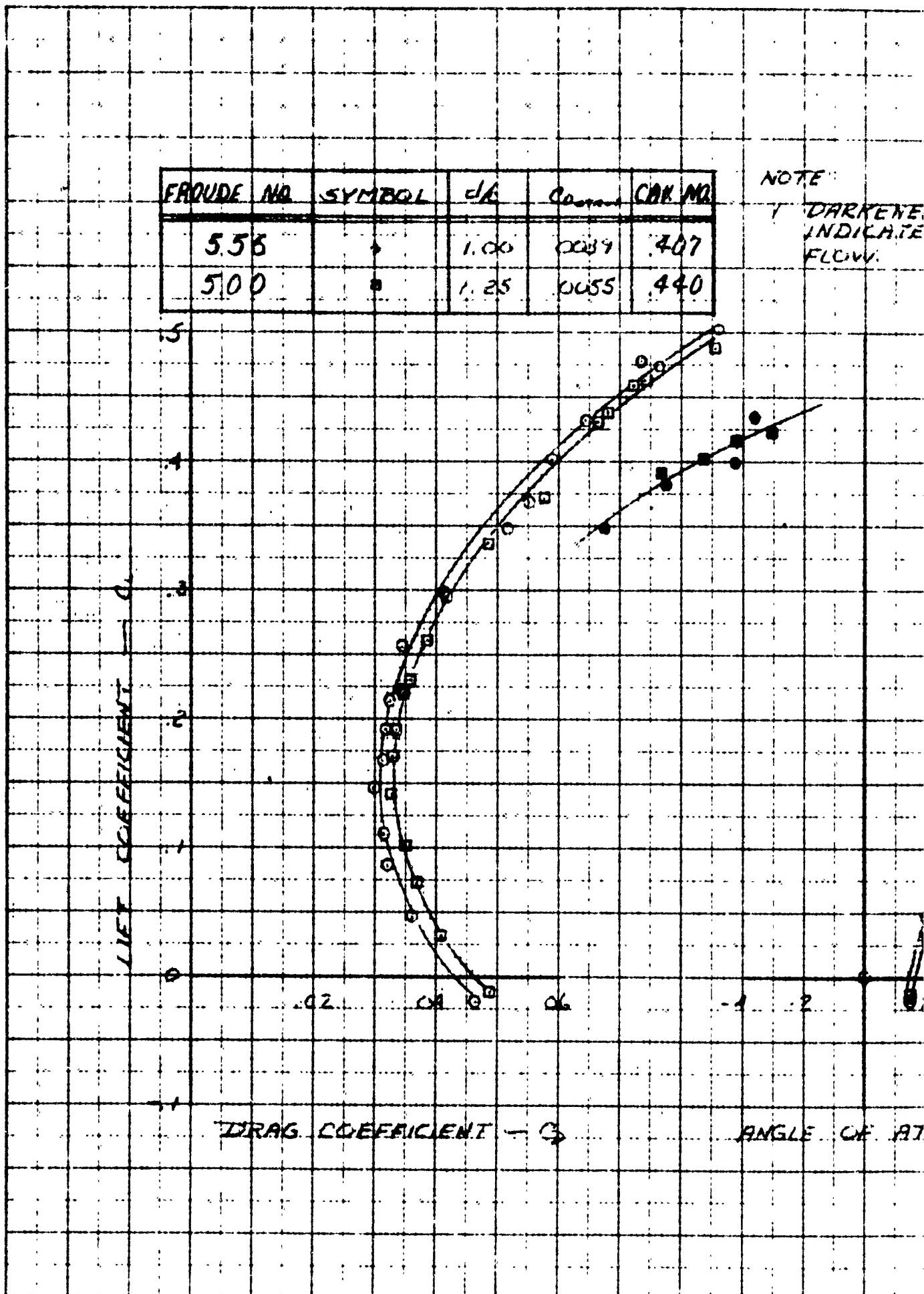
ARMED SYMBOLS
INDICATE VENTED FLOW



ATTACK - 0 - DEGREES

PITCHING MOMENT COEFFICIENT - C_{M0}

K-E 1000000000 1973



PAGE IV.9

WHIRLING TANK TEST NO. 202

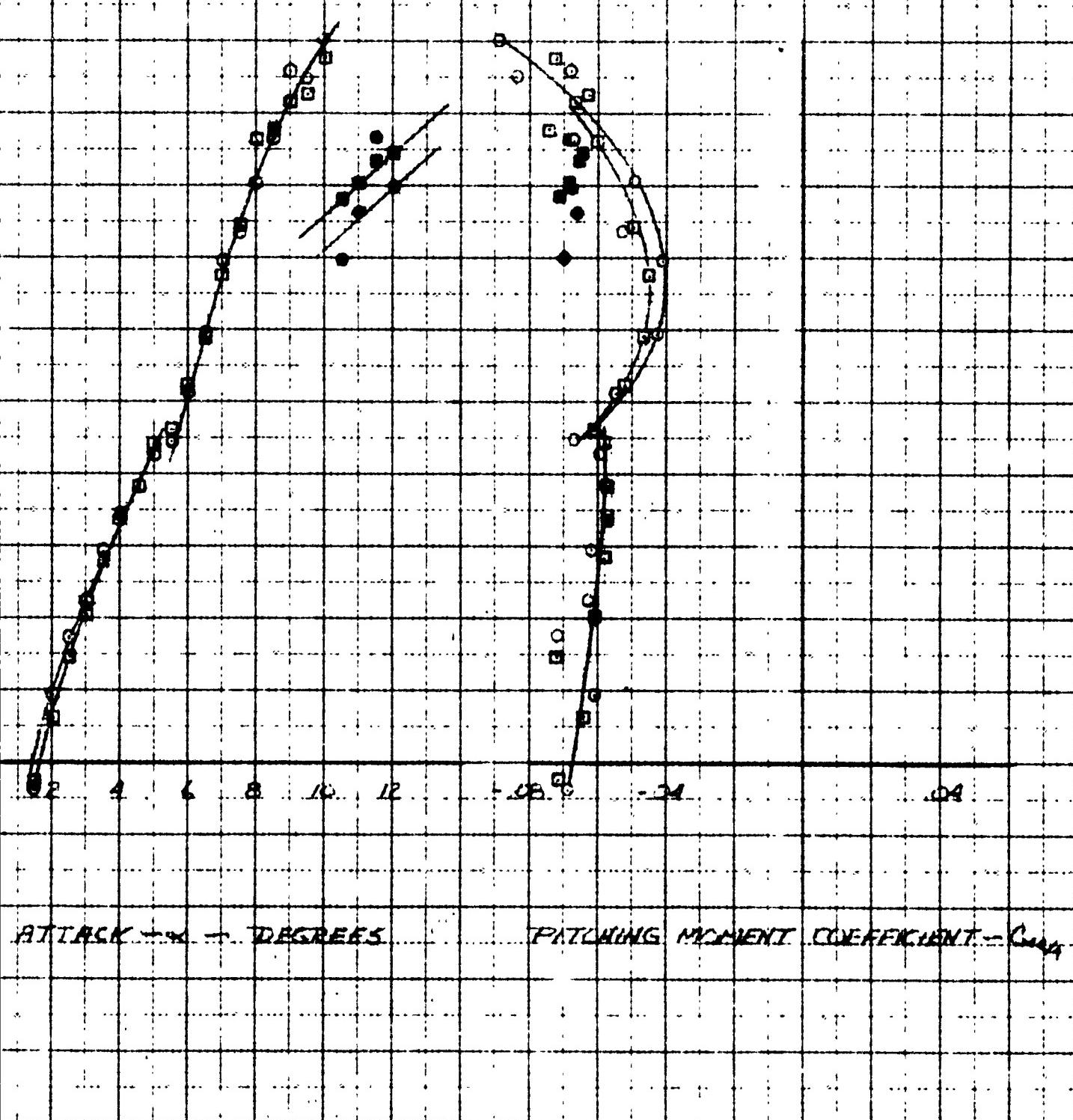
NO. 6 S 84454

MODEL NO. 8

45 KTS

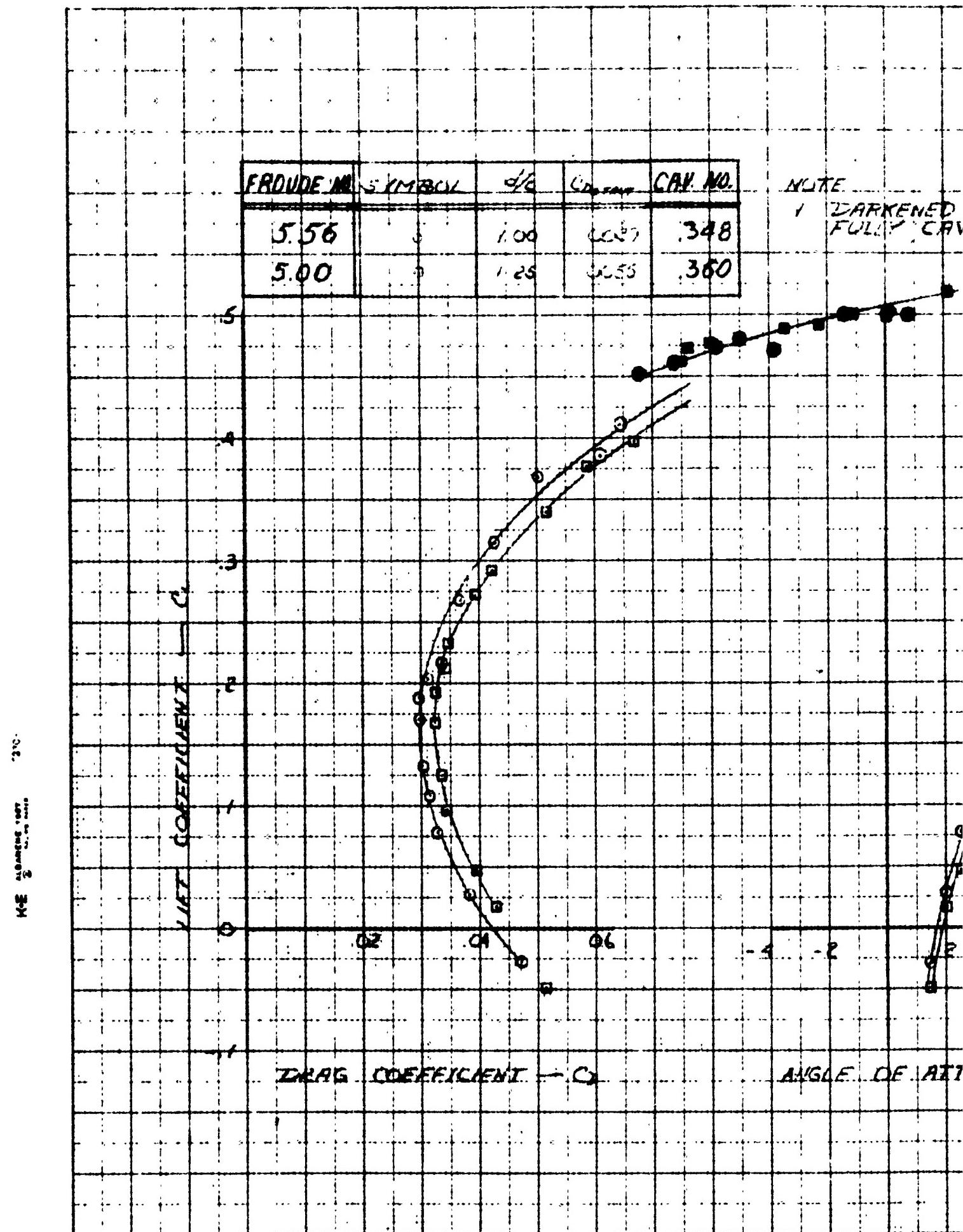
MAC = 137 FT

ENED SYMBOLS
ATE FULLY VENTED.



ATTACK α - DEGREES

PATCHING MOMENT COEFFICIENT - C_p



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WHIRLING TANK TEST NO. 202

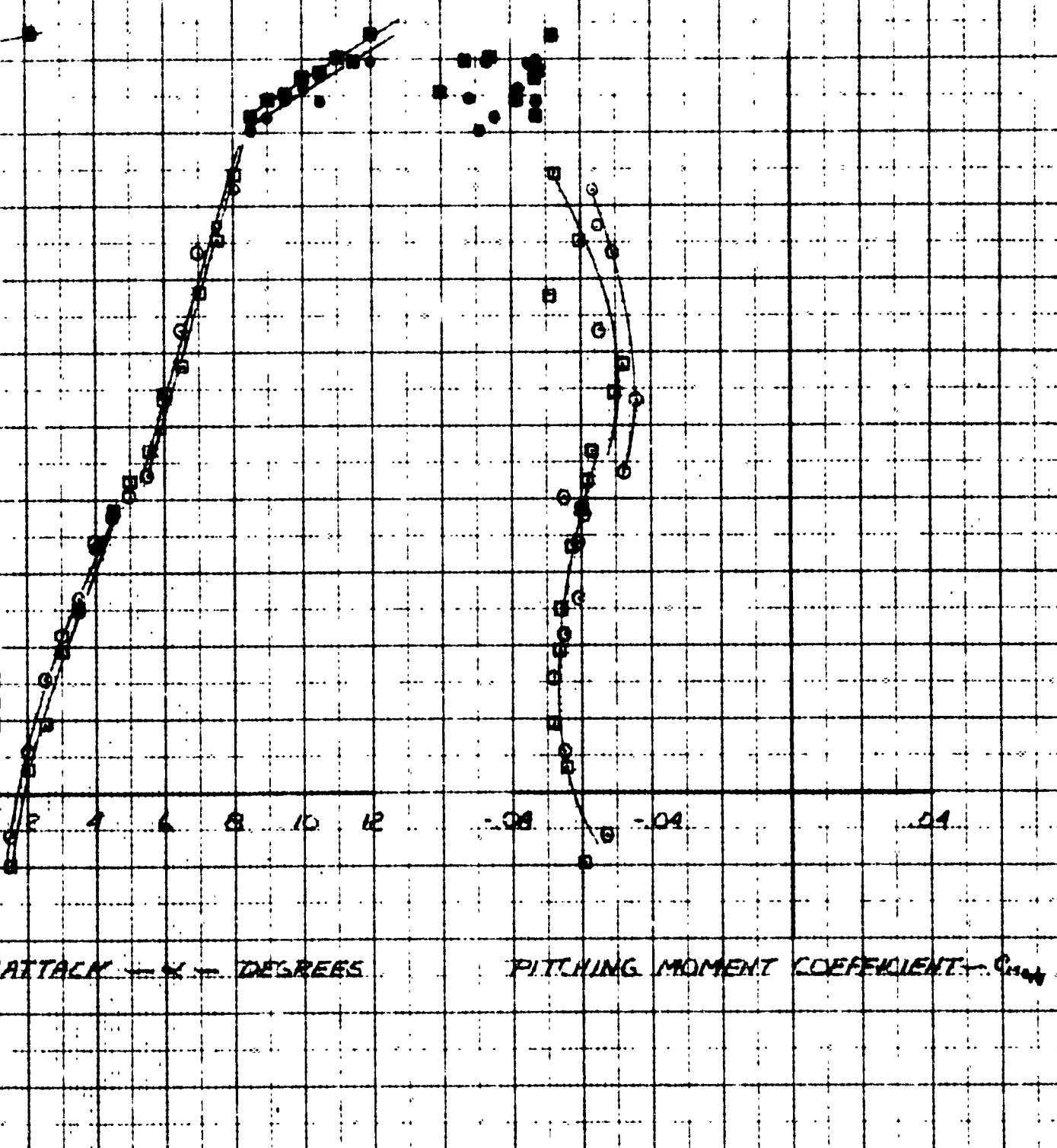
NUC. 84454

MODEL NO. 2

50 KTS

M.A.C. = 1.72 FT

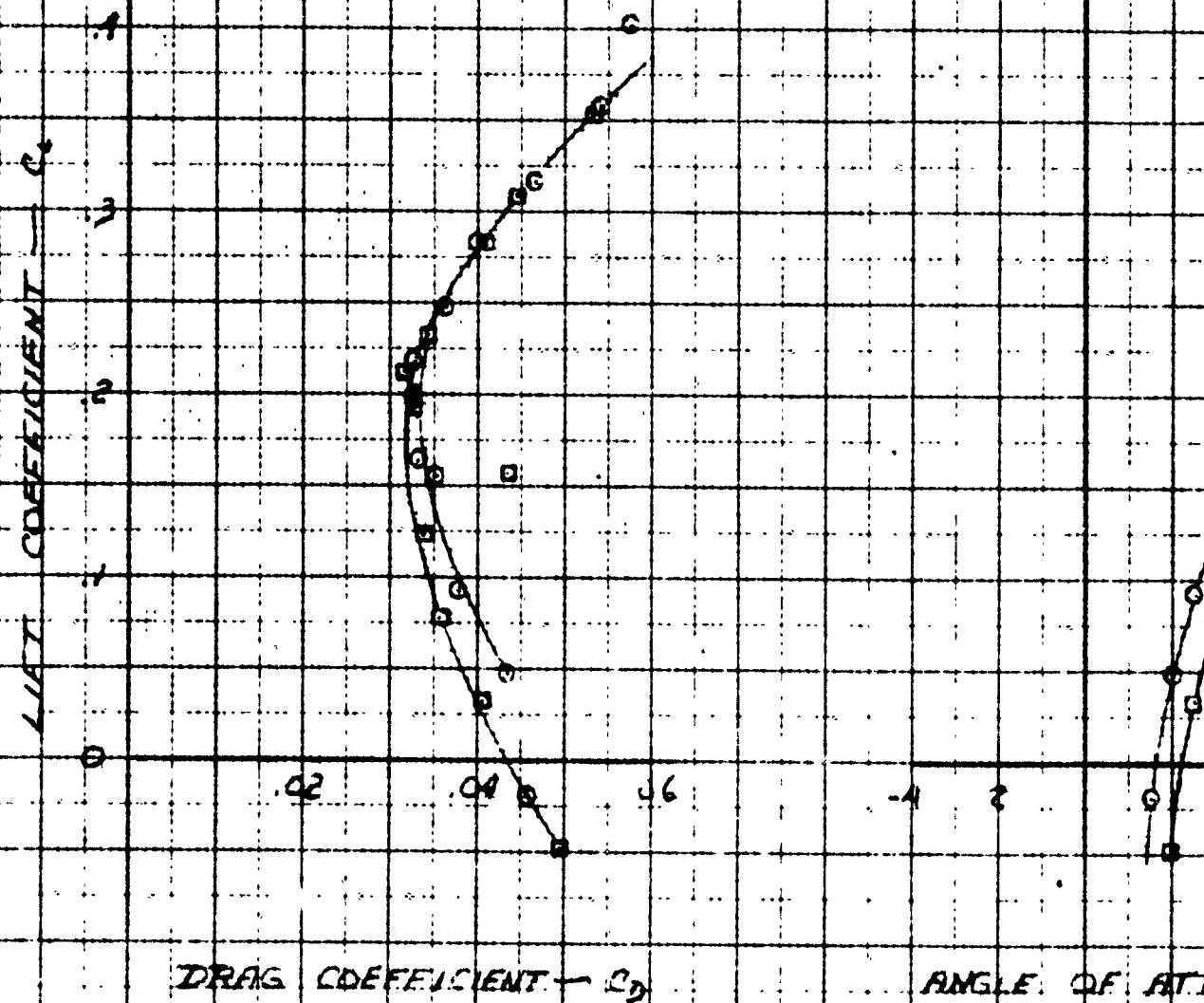
ED SYMBOLS INDICATE CAVITATED UPPER SURFACE



ME Starting 1987 -212

Froude No Cav No Sym Sol Jr Cams

5	.556	.259	1.00	0.039
	500	.275	1.25	0.053



1935 Ld 10

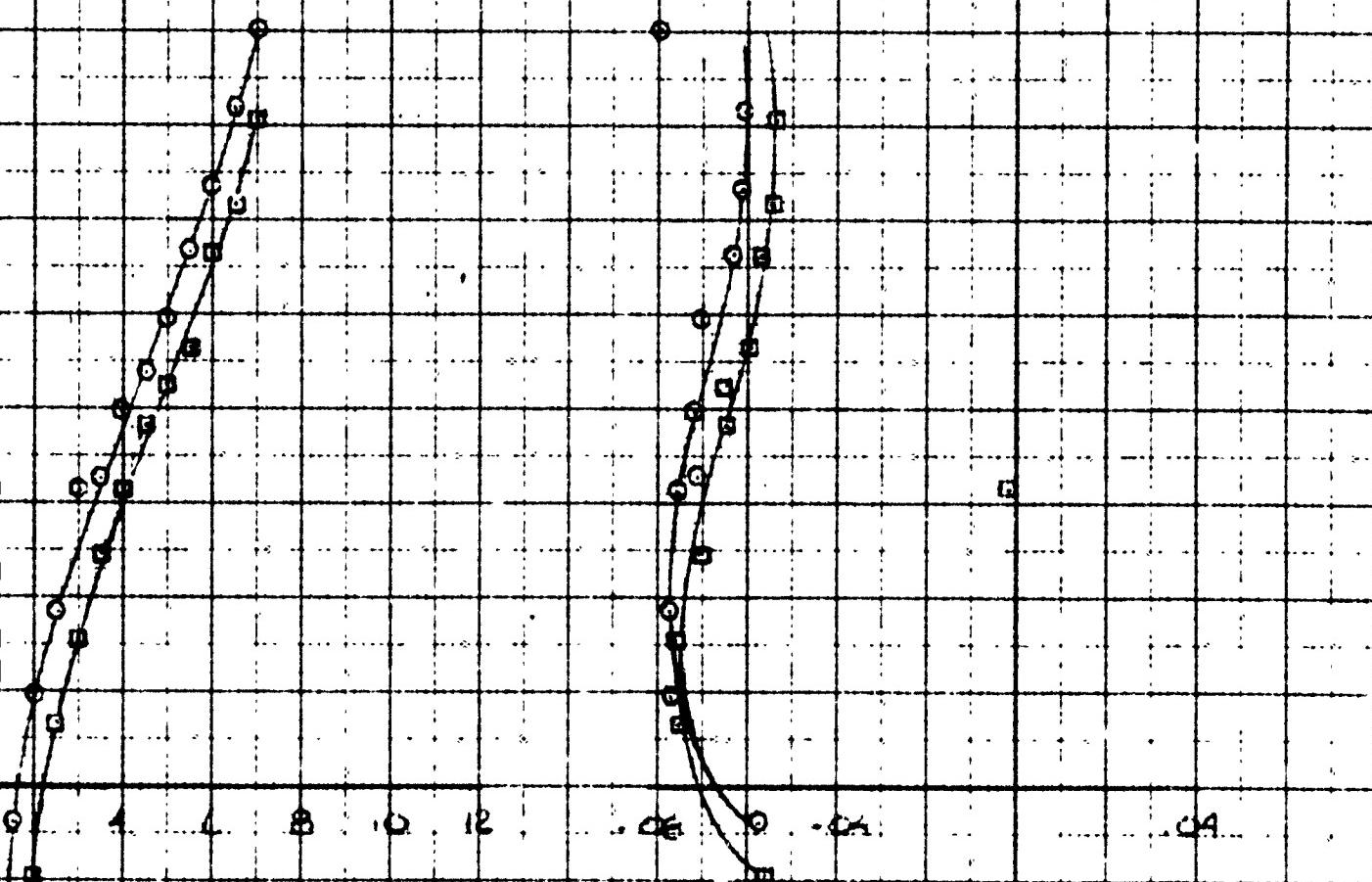
WHIRLING TANK TEST NO. 20

NO 65 24454

MODEL NO 2

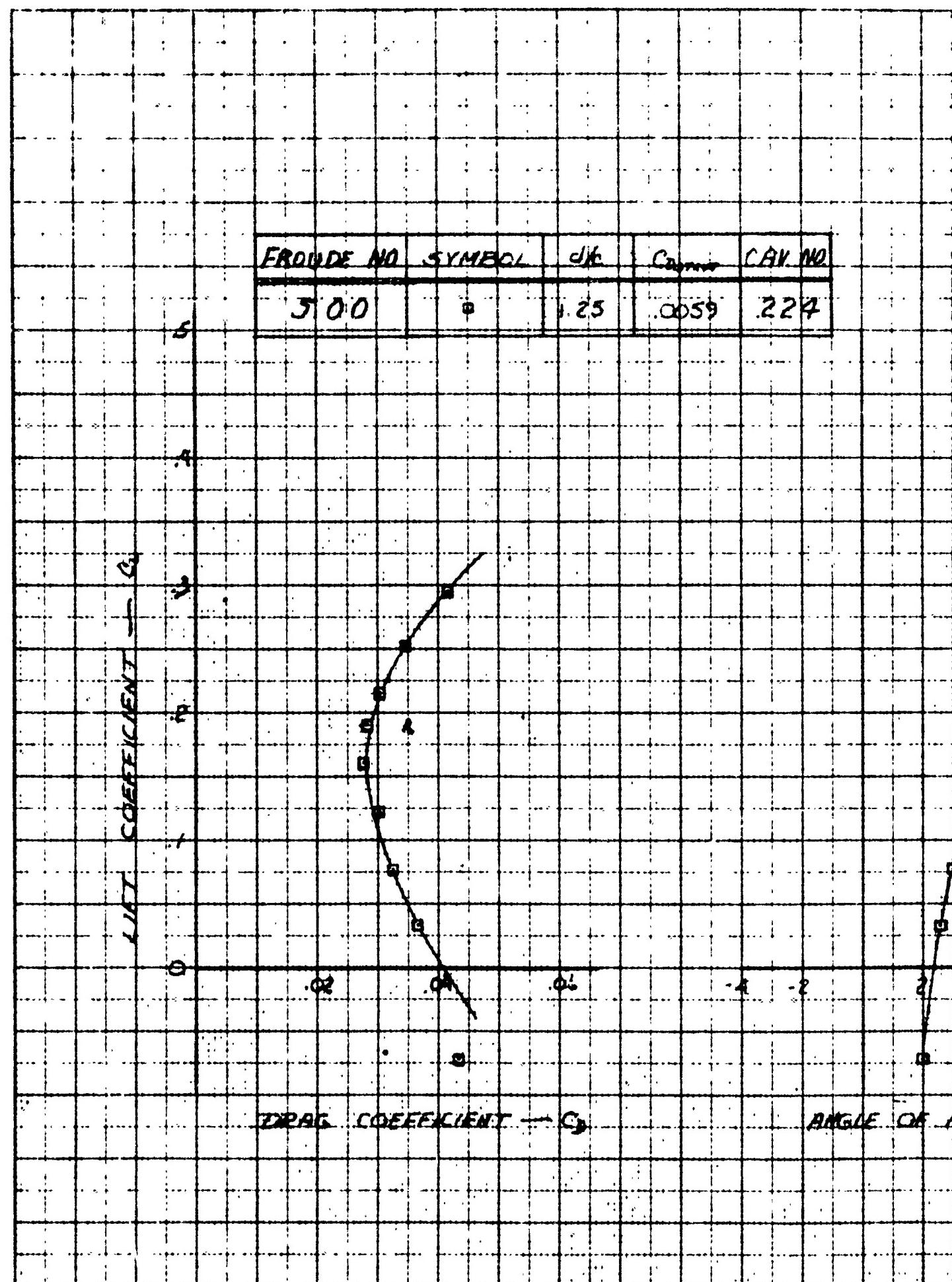
60 KTS.

M.A.C. = 1.79 FT



ATTACK -- DEGREES

PITCHING MOMENT COEFFICIENT - Cg



PAGE IV.11

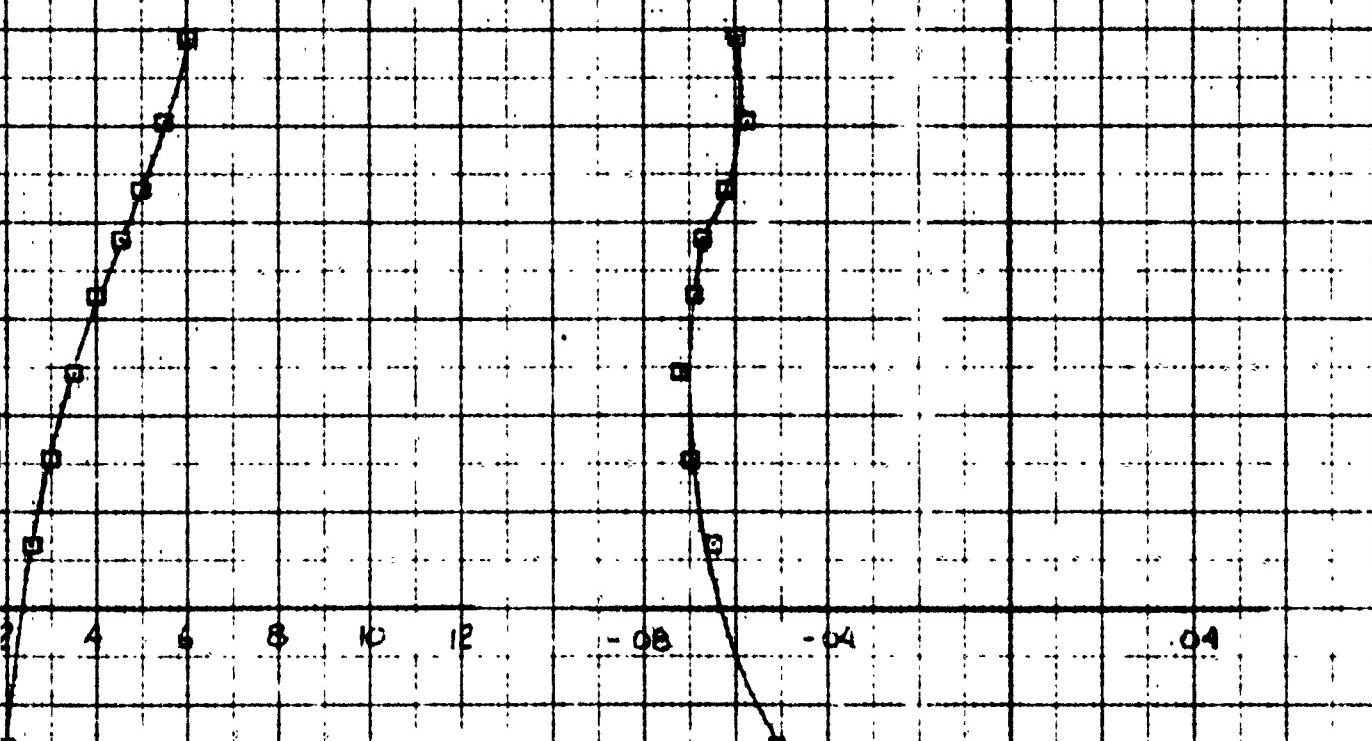
WHEELING TANK TEST NO. 20.

NO. 4 S. SAMSON

MODEL NO. 2

70 KTS.

M.E.C. = 137 FT

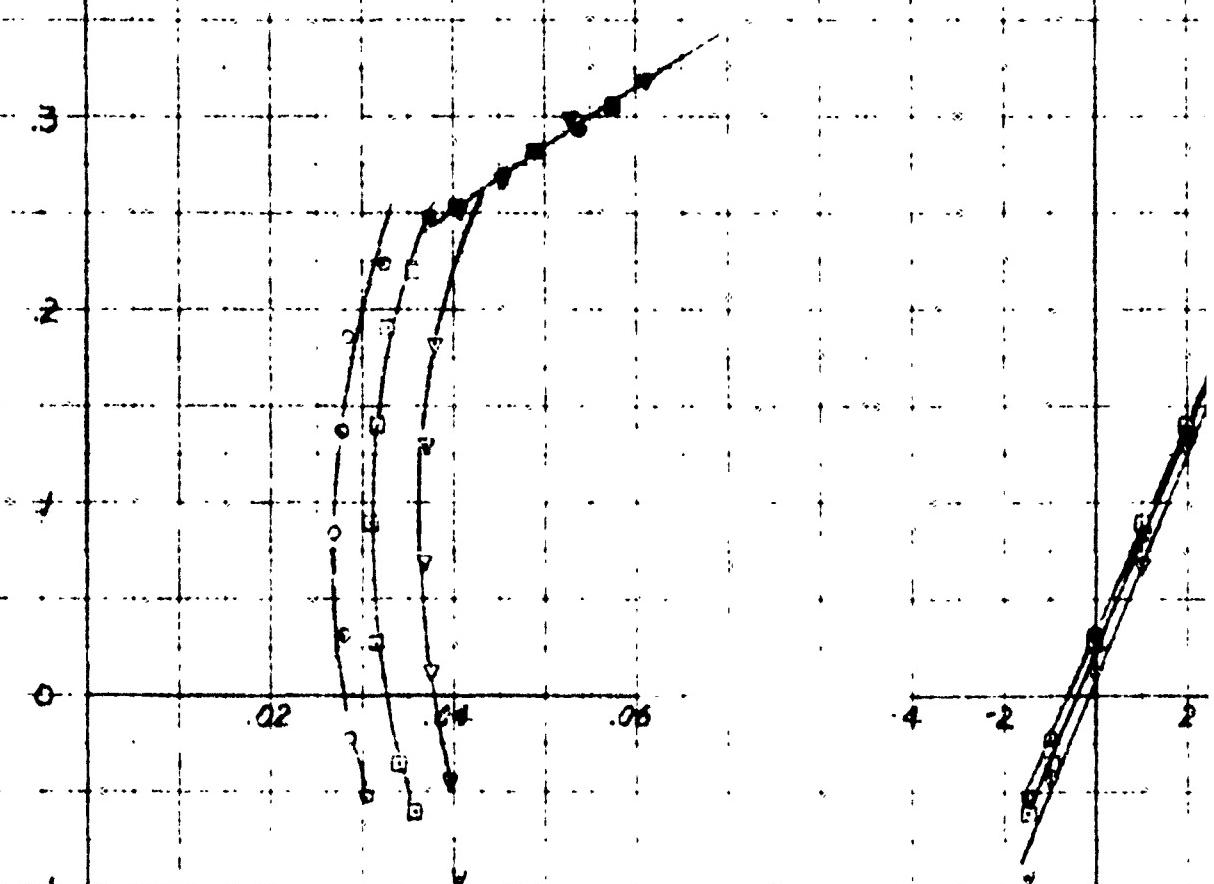


ANGLE OF ATTACK - DEGREES

PITCHING MOMENT COEFFICIENT - C_m

FROUDE NO.	SYMBOL	$\frac{V}{C}$	C_D STRUT	CH NO	NOTE
6.12	O	75	.0023	429	
5.32	□	100	.0034	515	
4.79	V	1.25	.0053	532	

LIFT COEFFICIENT - C_L



DRA G COEFFICIENT

C_D

PAGE 11

WHIRLING TANK TEST NO 20H

NO 05 84454

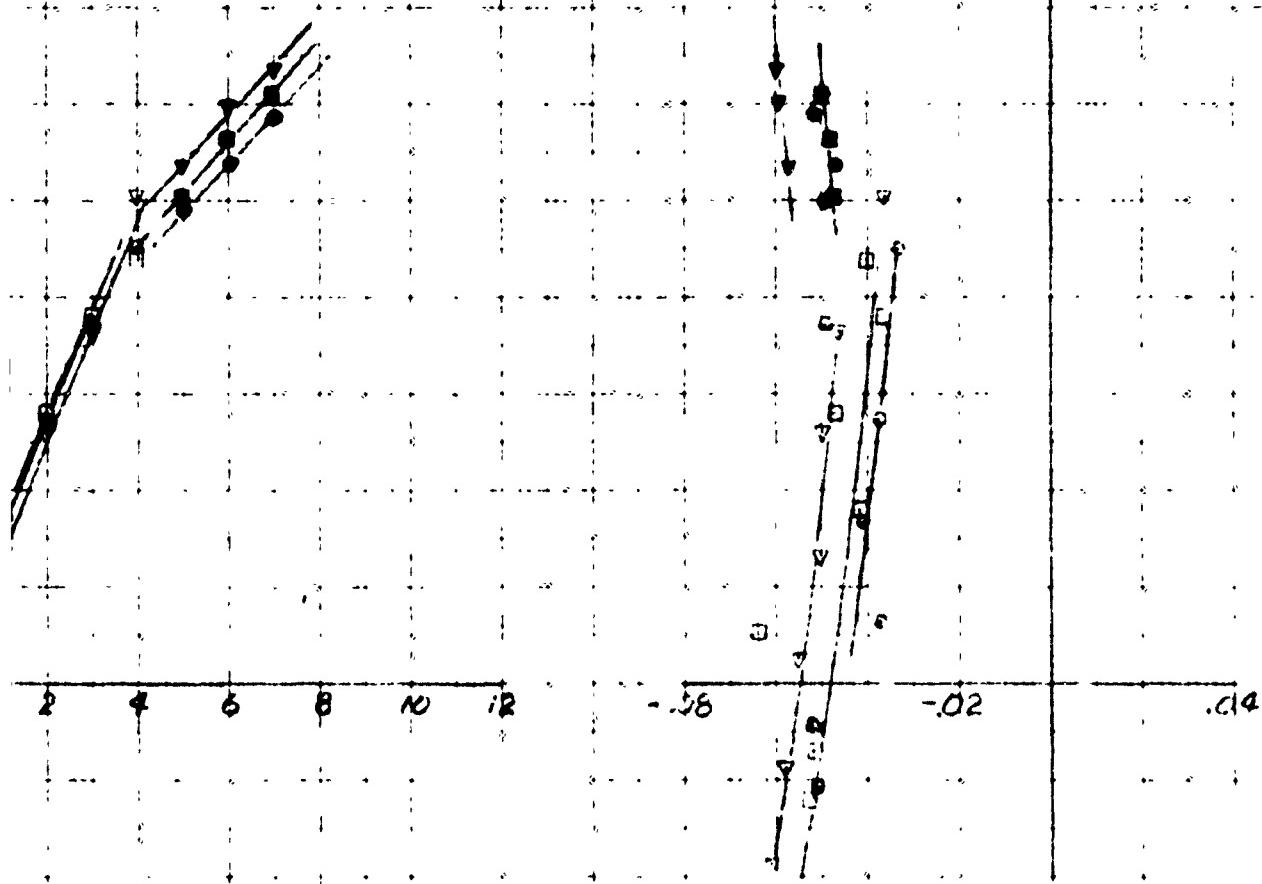
MODEL NO. 3

60 HZ.

M.H.L. = 15.2 FT.

1. DARKENED SYMBOLS INDICATE
VENTED FLOW.

TE:



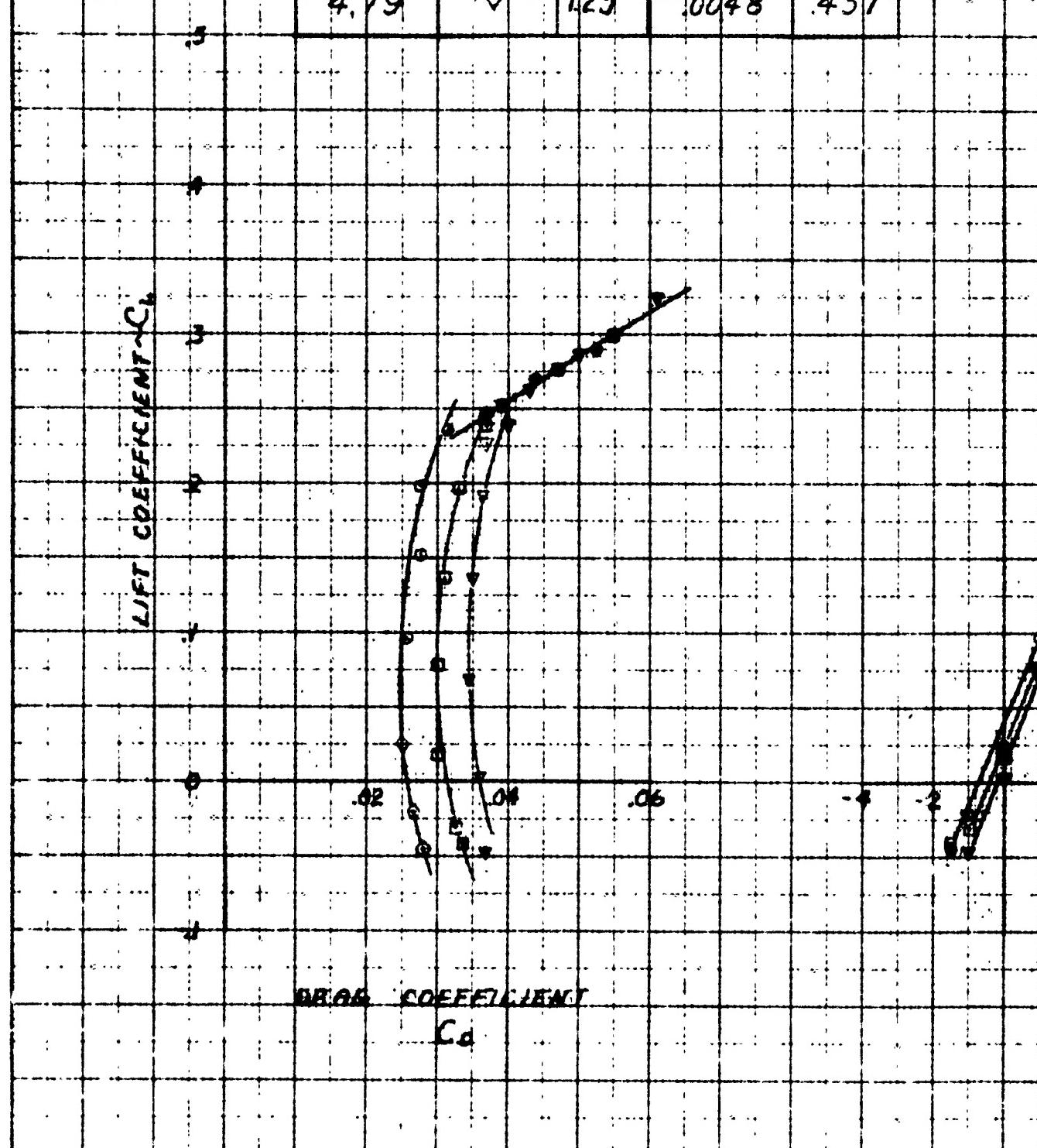
ANGLE OF ATTACK
alpha - DEGREES

PITCHING MOMENT
COEFFICIENT - CM_c

REPORT NO.

FROUDE NO.	SYMBOL	C_L/C_D	C_D STAB	CAV NO.
------------	--------	-----------	------------	---------

5.12	○	.75	.0021	.408
5.32	□	1.00	.0036	.424
4.79	▽	1.25	.0048	.437



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WHIRLING TANK TEST NO. 204

NO. 65 B4454

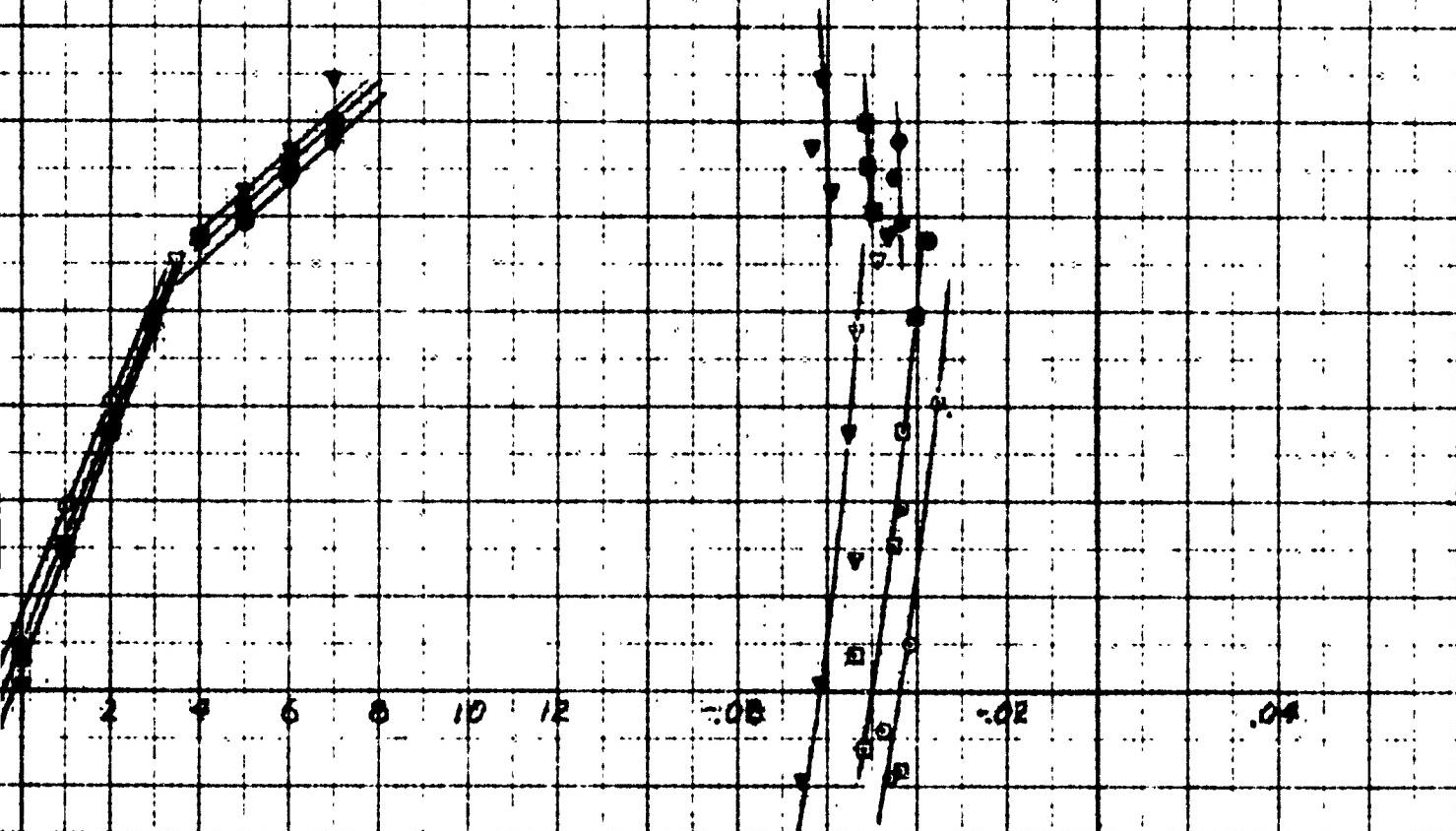
MODEL NO. 3

45 H.P.S.

M.A.C. = 152 FT

NOTE:

1. DARKENED SYMBOLS INDICATE
VENTED FLOW.



ANGLE OF ATTACK
IN DEGREES

PITCHING MOMENT

COEFFICIENT ~ C_m

REPORT NO.

SYMBOL +/_{1/2} COEFFICIENT PROVIDE NO. CAV. NO.

○	75	.0024	0.12	.345	NO
□	100	.0039	5.32	.354	
▽	125	.0054	4.79	.370	

LIFT COEFFICIENT - C_L

DRAUG COEFFICIENT
 C_d

GRUMMAN AIRCRAFT

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WHIRLING TANK TEST NO. 204

NO. 6.S. B4454

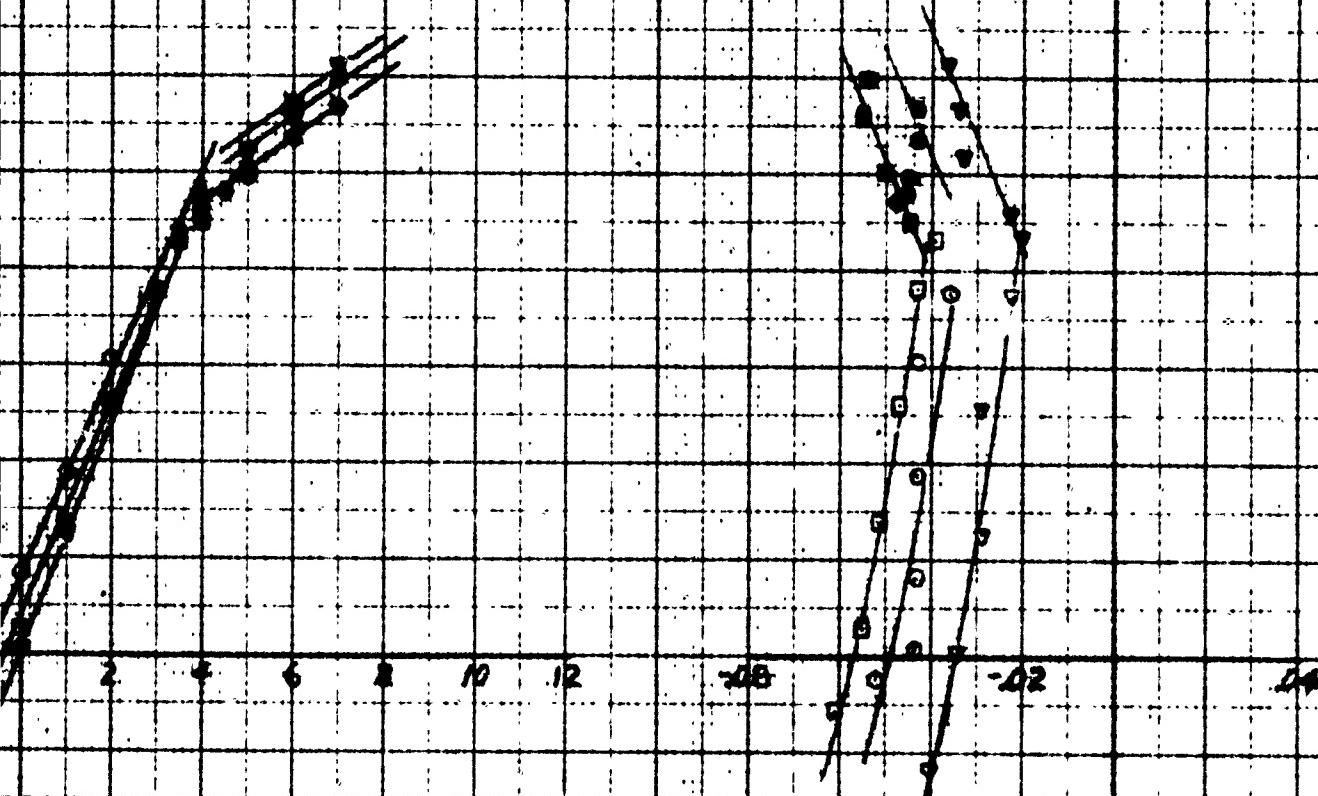
MODEL NO. 3

50 KTS.

MRC = 1.52 FT

NOTE:

1. DARKENED SYMBOLS INDICATE
WANTED FLOW.



ANGLE OF ATTACK
in. - DEGREES

PITCHING MOMENT
COEFFICIENT - CMc

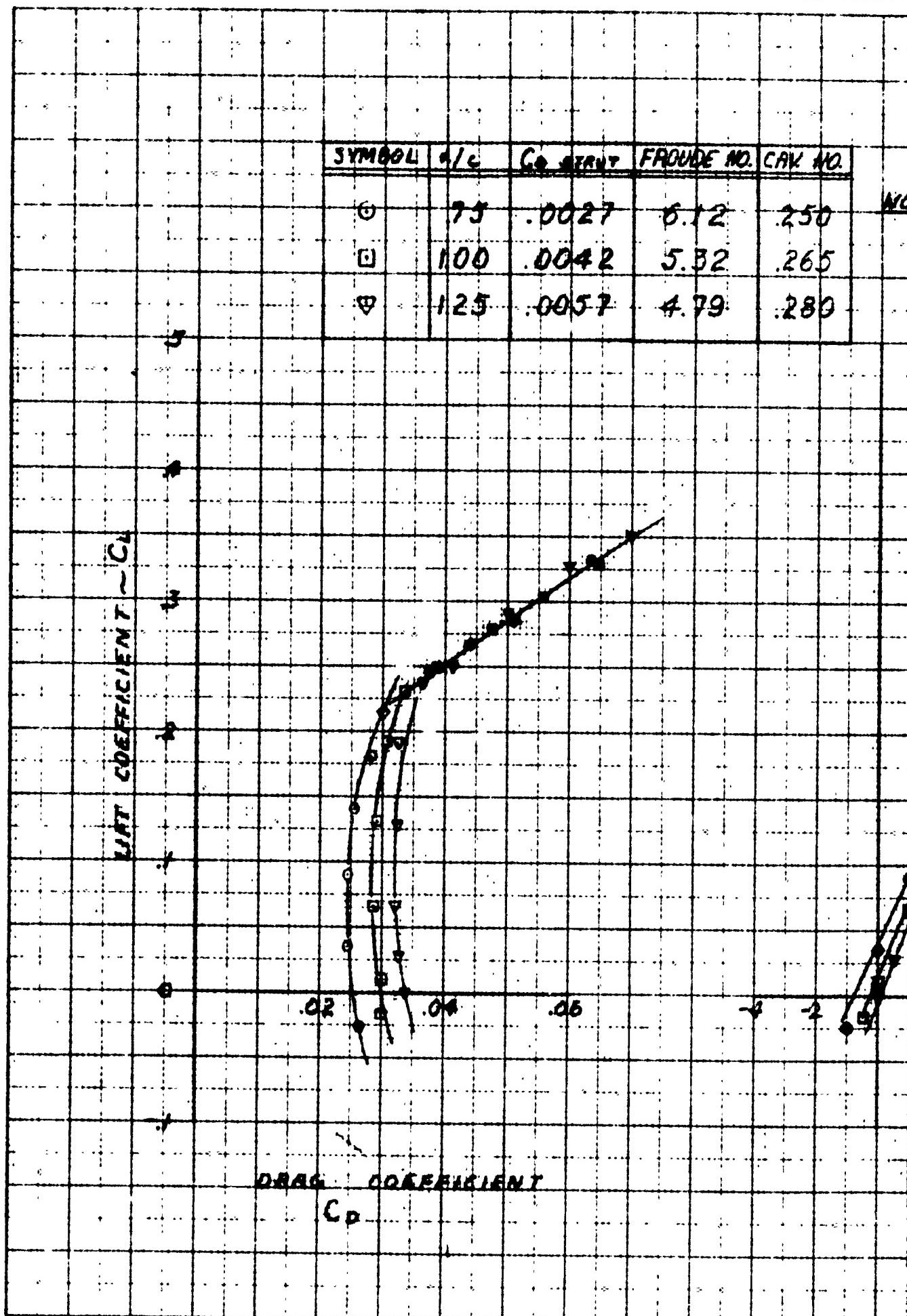
REPORT NO.

SYMBOL	α / C	C_d STAB	FROUDE NO.	CAV NO.
--------	--------------	------------	------------	---------

○	75	.0027	5.12	.250
□	100	.0042	5.32	.265
▽	125	.0057	4.79	.280

LIFT COEFFICIENT - C_L

DRAKE COEFFICIENT
 C_D



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WHIRLING TANK TEST NO 20H

NO. 65 34454

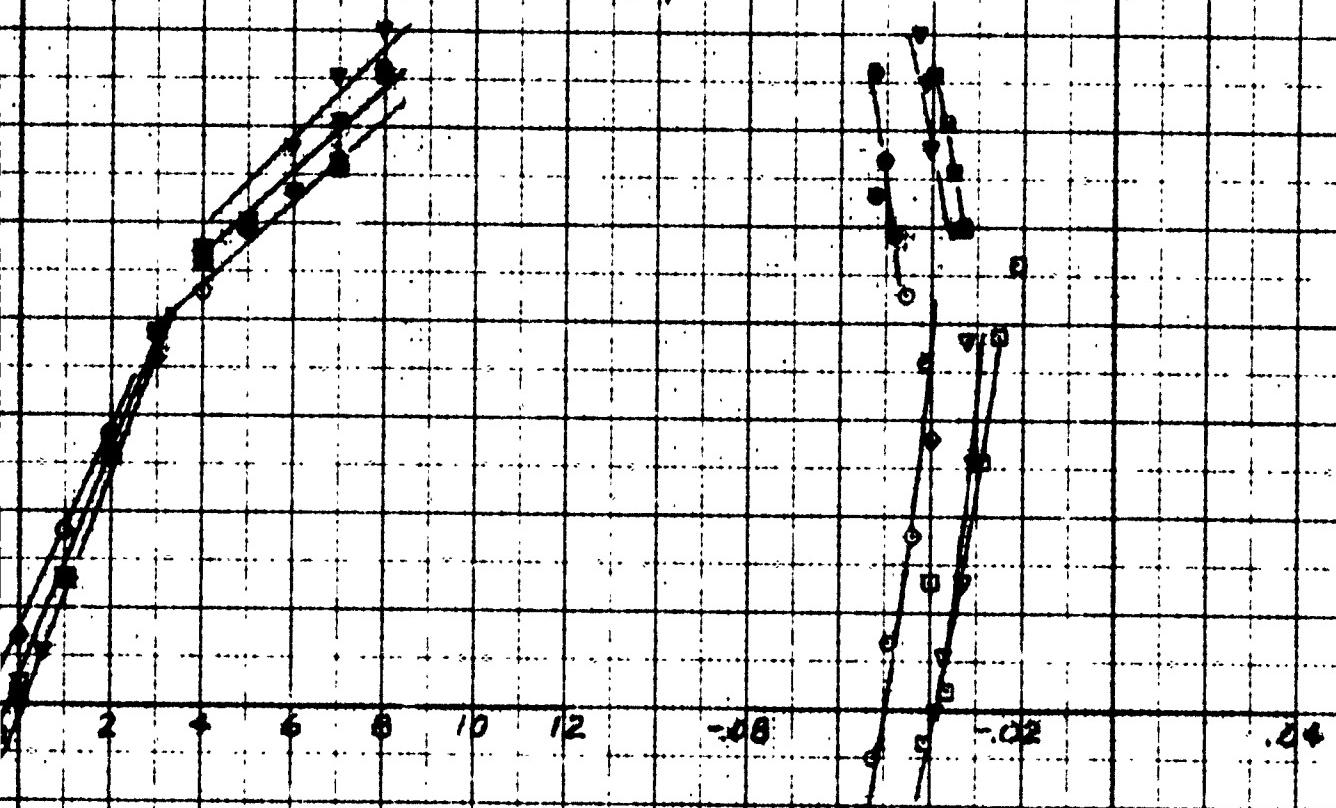
MODEL NO. 3

60 H.P.

M.A.C. 4152 FT

NOTE:

U DARKENED SYMBOLS INDICATE
VENTED FLOW.



ANGLE OF ATTACK
IN DEGREES

PITCHING MOMENT
COEFFICIENT - C_m

REPORT NO.

LIFT COEFFICIENT - C_L

DRAG COEFFICIENT
 C_D

SYMBOL	C_L	C_D STRUT	FROUDE NO	CAV. NO.
○	75	.0029	0.12	199
□	100	.0042	5.32	215
△	125	.0056	4.79	232

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WHIRLING TANK TEST NO. 20H

NO. DS B4454

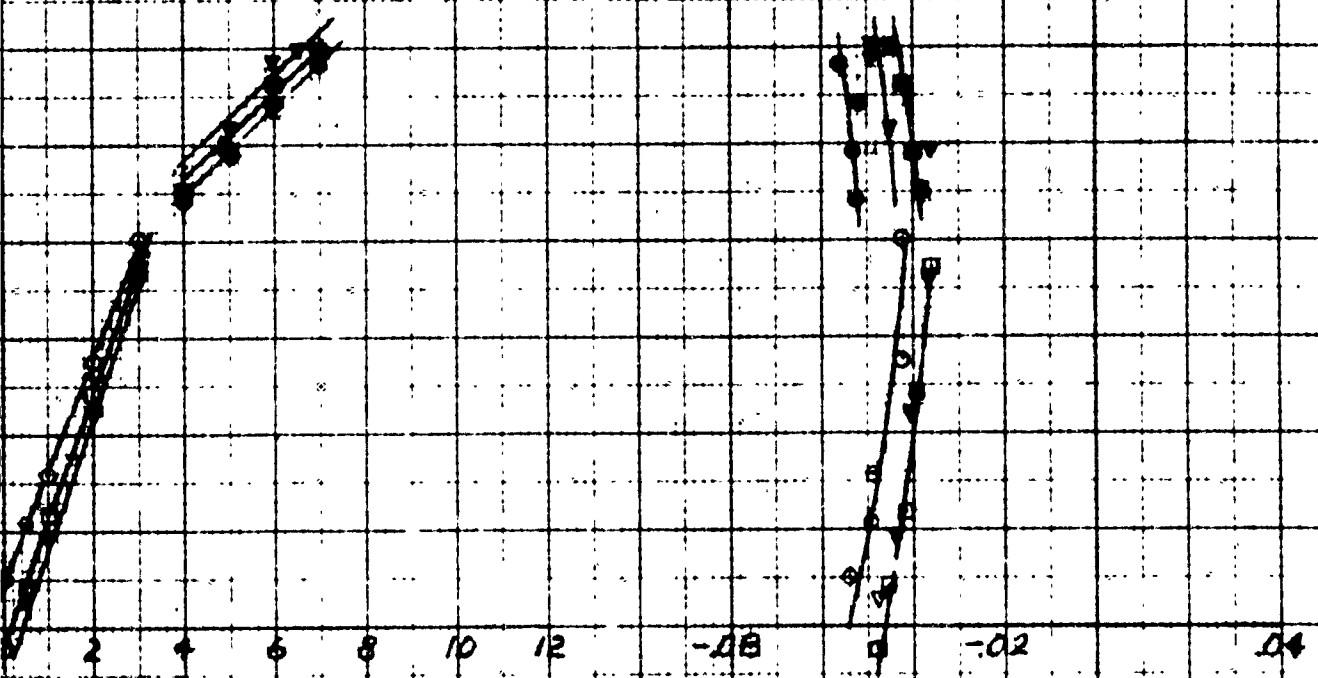
MODEL NO. 3

70 KTS.

M.A.C. E. 152 Ft.

NOTE:

A DARKENED SYMBOLS INDICATE
VENTED FLOW.



ANGLE OF ATTACK
IN DEGREES

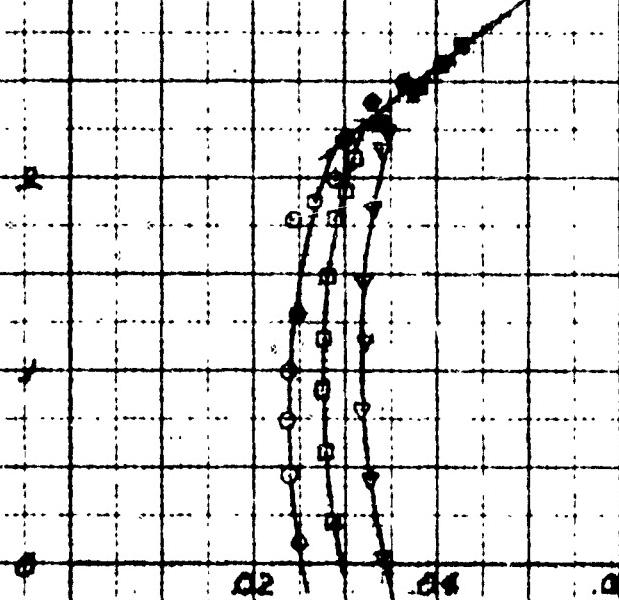
PITCHING MOMENT
COEFFICIENT - CM_q

REPORT NO

FREUDEN NO	SCHOOL	α_1	C_d	STRUT	CAV NO.
------------	--------	------------	-------	-------	---------

0.12	○	75	0027	177
5.32	□	100	0042	192
4.79	△	125	0050	210

LIFT COEFFICIENT - C_L



DRAg COEFFICIENT
 C_d

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WHIRLING TANK TEST NO. 20H

NO. 65 84454

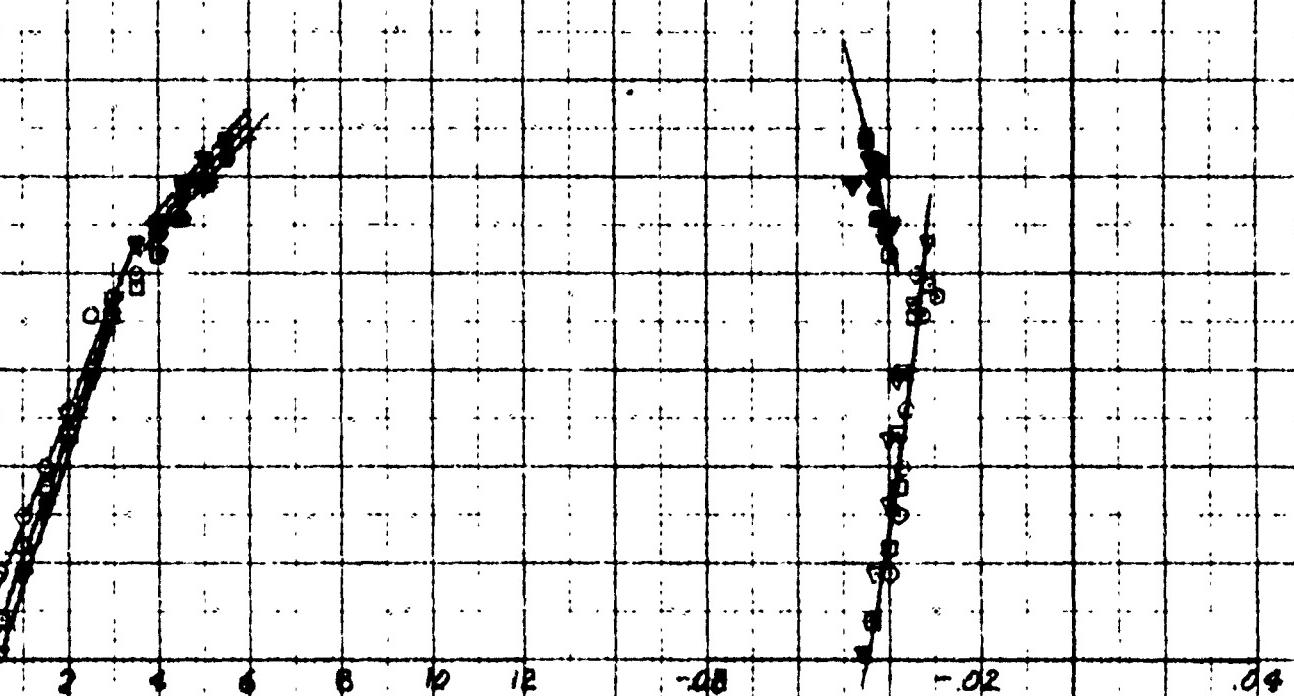
MODEL NO. 3

80 KTS.

MAC. +152 FT

NOTE:

1-DARKENED SYMBOLS INDICATE
VENTED FLOW.



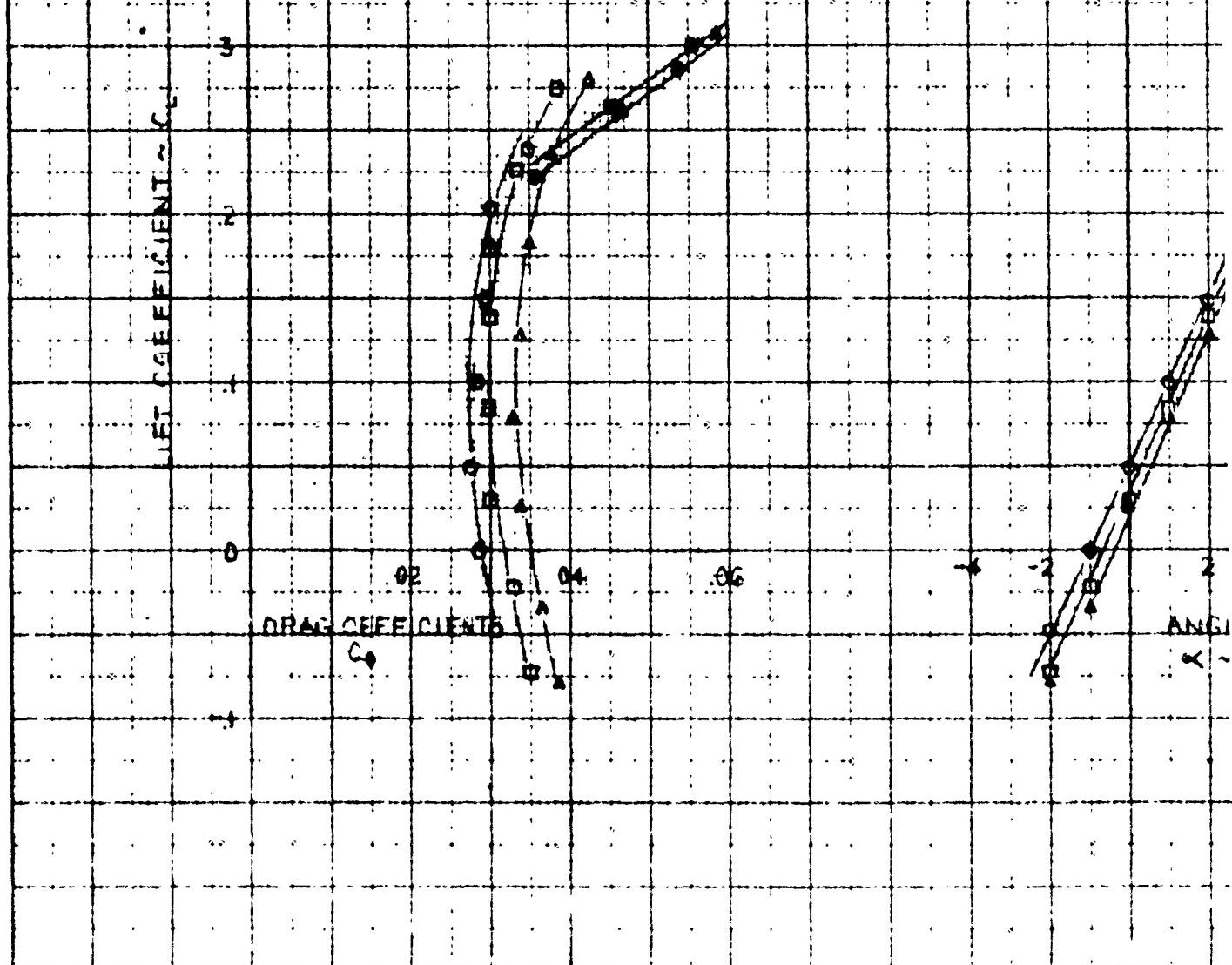
REPORT NO.

FROUDE NO.	SYMBOL	d/c	COEFF. - CAV. No.
---------------	--------	-----	-------------------

6.2913	○	.75	0019 493
5.4682	□	1.00	0027 511
4.9141	△	1.25	0042 517

N.C.F.E.

1.CA



GRUMMAN AIRCRAFT ENGINE

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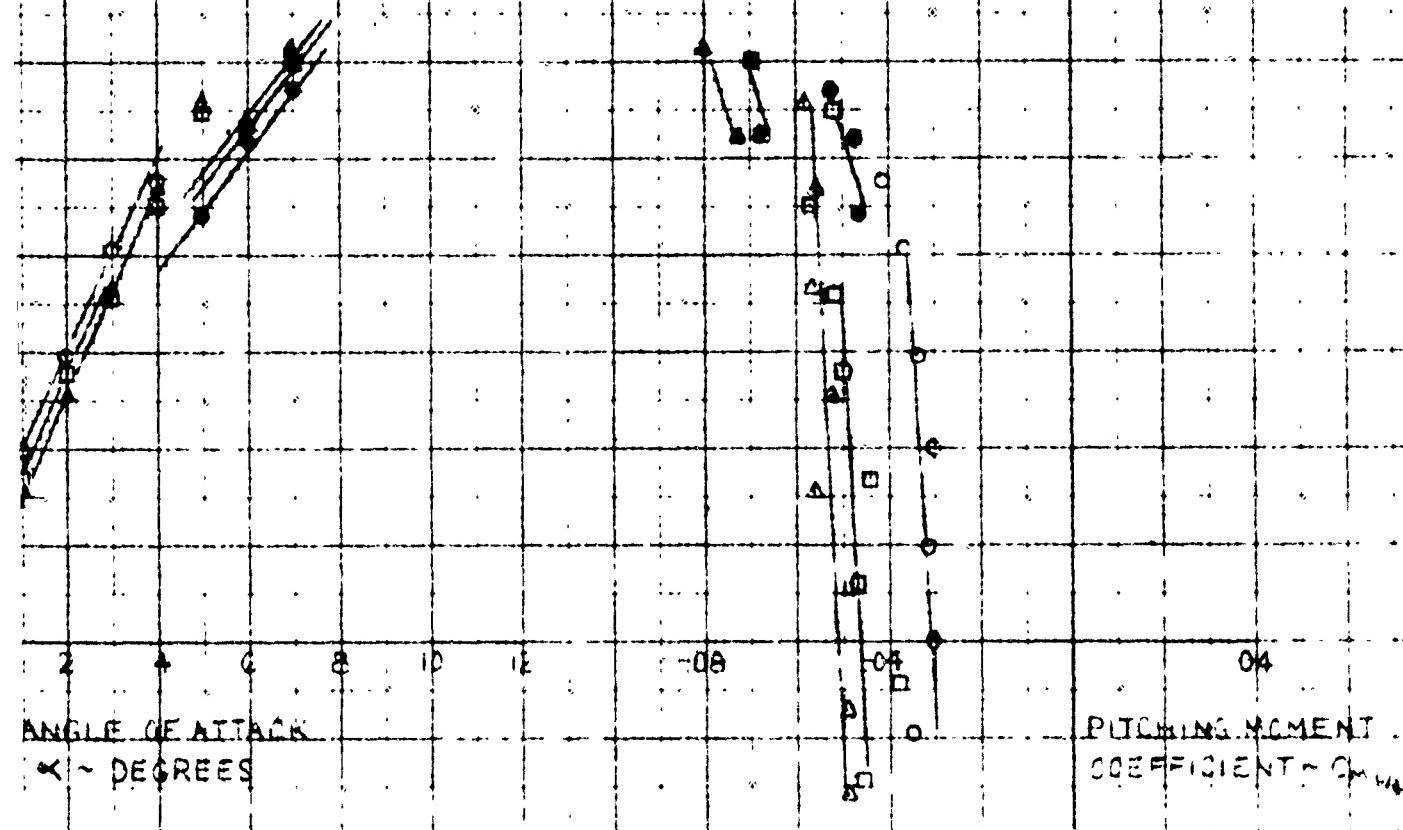
WHIRLING TANK TEST NO 246

BUSHIPS NO 4

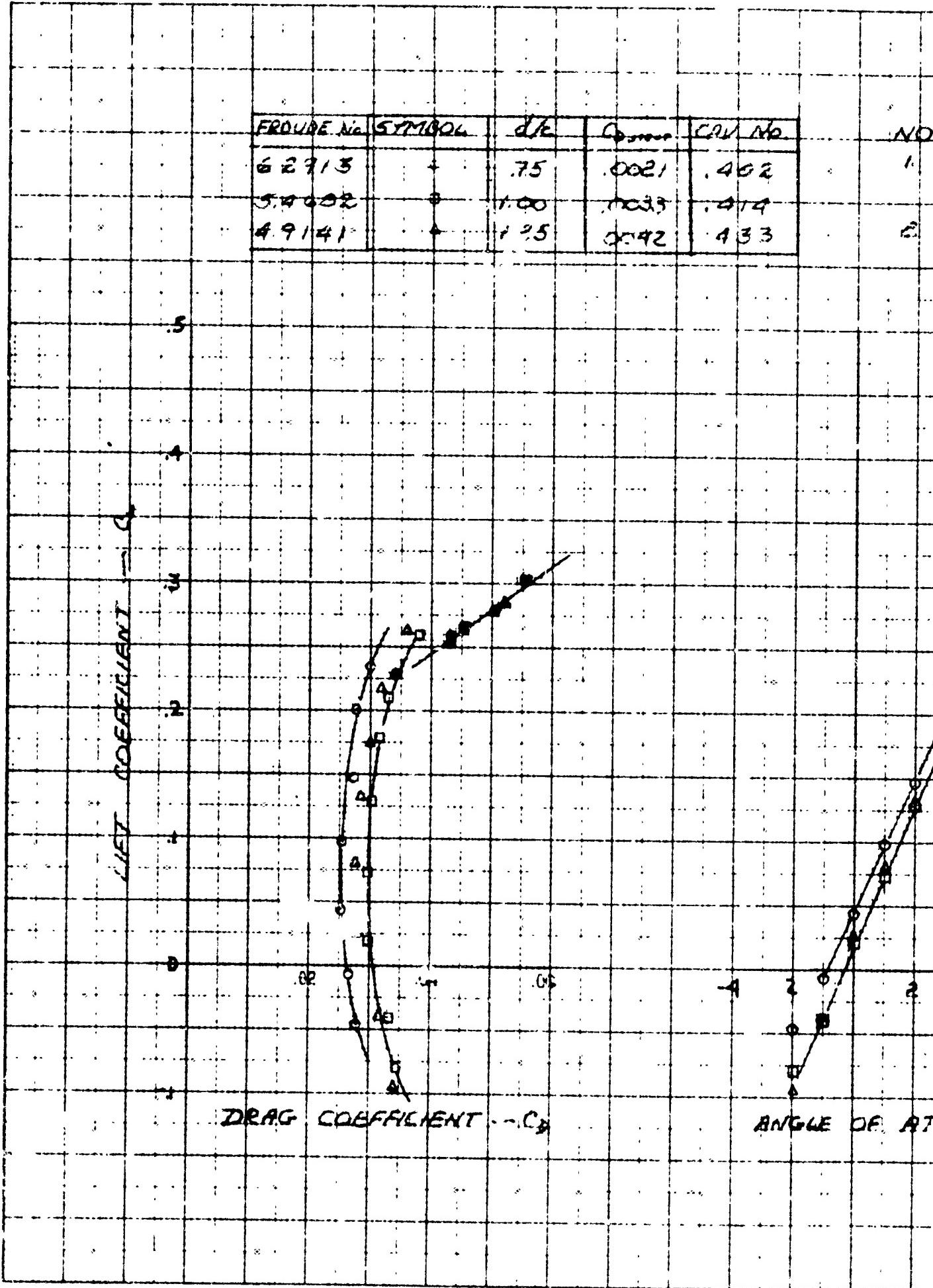
40 KTS

MAC = 194 FT

1. DARKENED SYMBOLS INDICATE
NEUTRAL FLOW



REPORT NO



NOTE

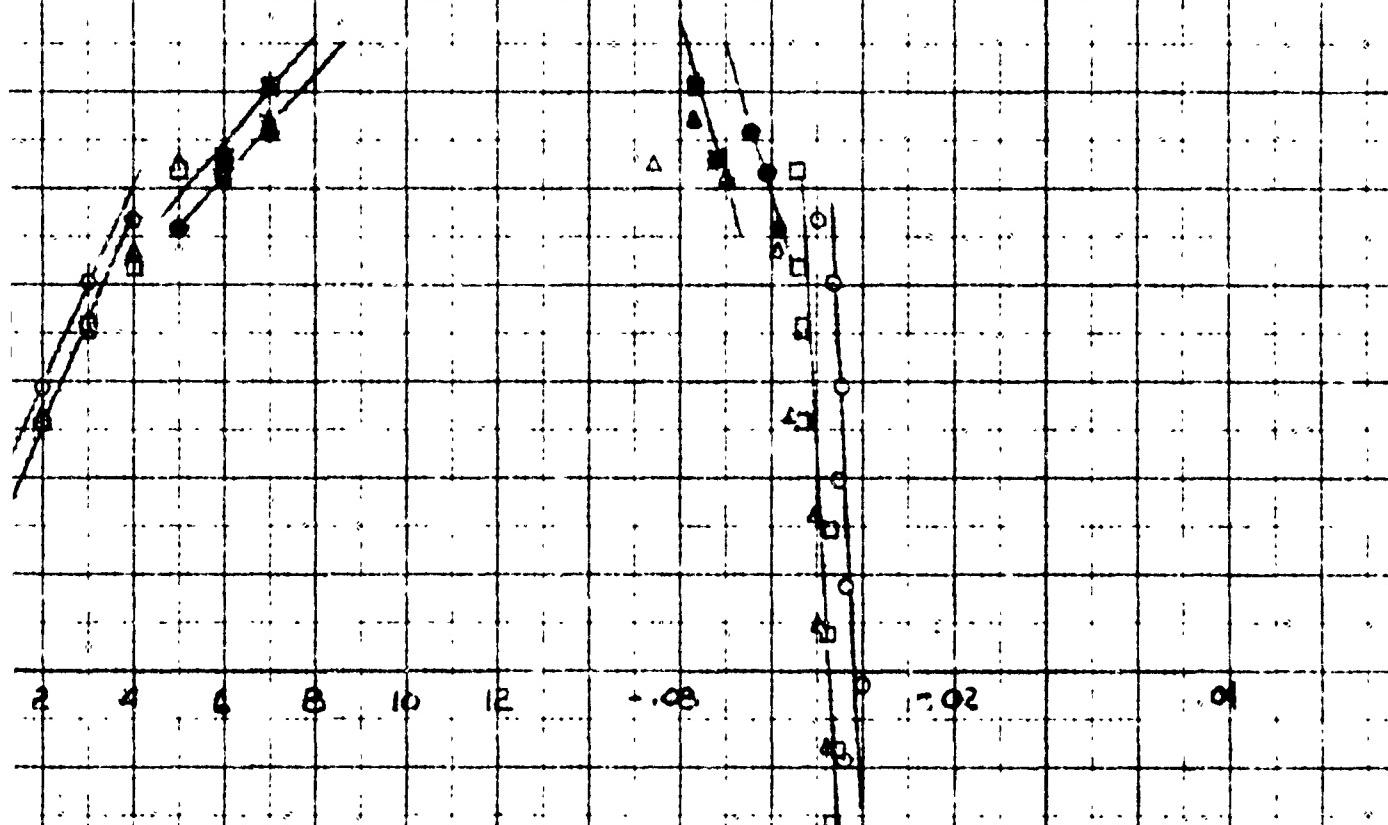
1. DARKENED SYMBOLS INDICATE
VENTED FLOW

WHIRLING TANK TEST NO 203

BUCHIPS NO 4
45 KTS

2. DATA @ SLE = 12.5 IS OPEN
TO QUESTION.

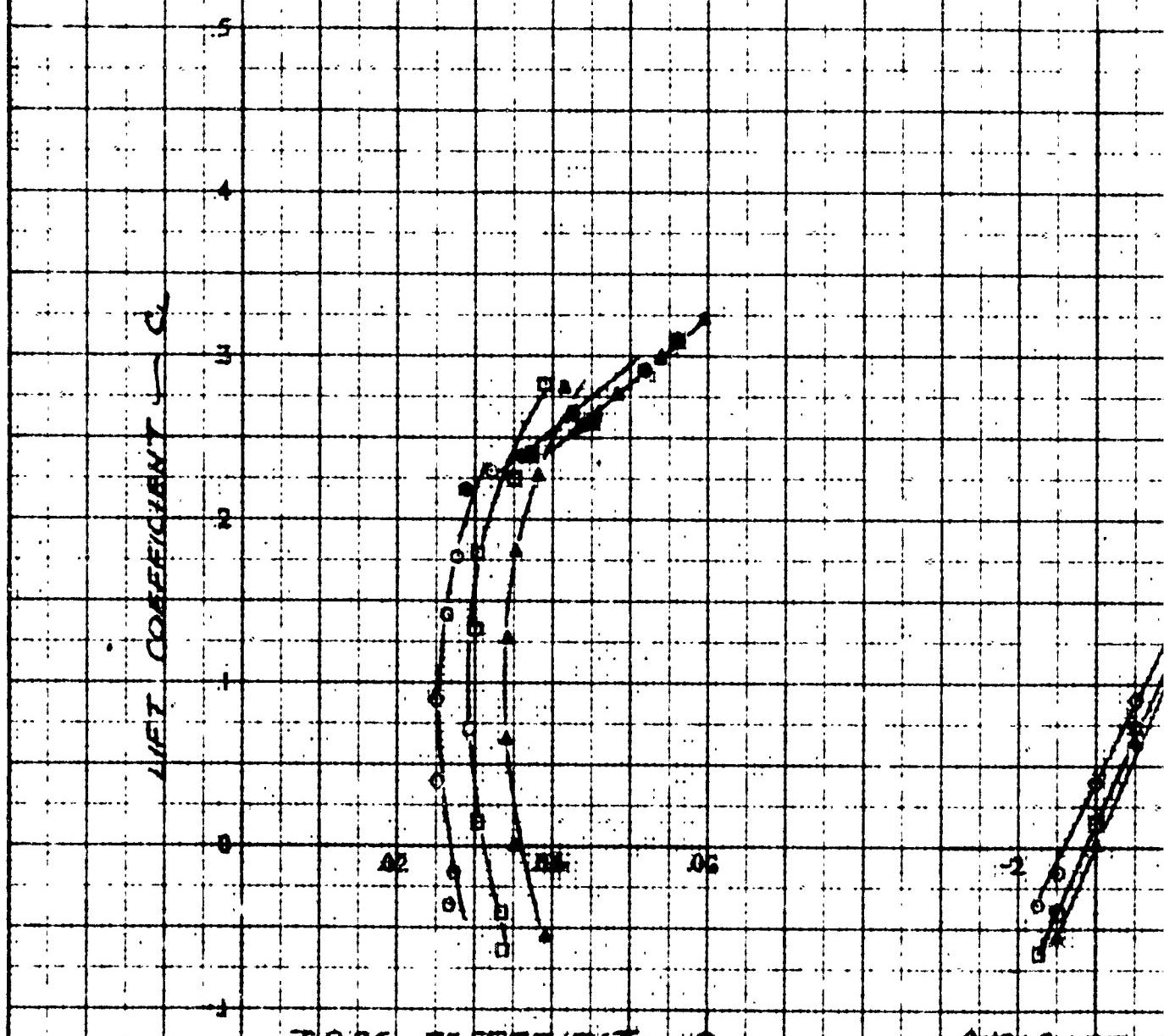
M.A.C = 12.4 FT.

ATTACK - α - DEGREESPITCHING MOMENT COEFF - C_m

FROUDE NO.	SYMBOL	A/C	COEFFICIENT	CAV. NO.
6.2818	Φ	.75	G022	337
5.4698	Φ	1.00	0034	348
9.9191	↑	1.25	0040	366

NOTE

1.1



GRUMMAN AIRCRAFT ENGR

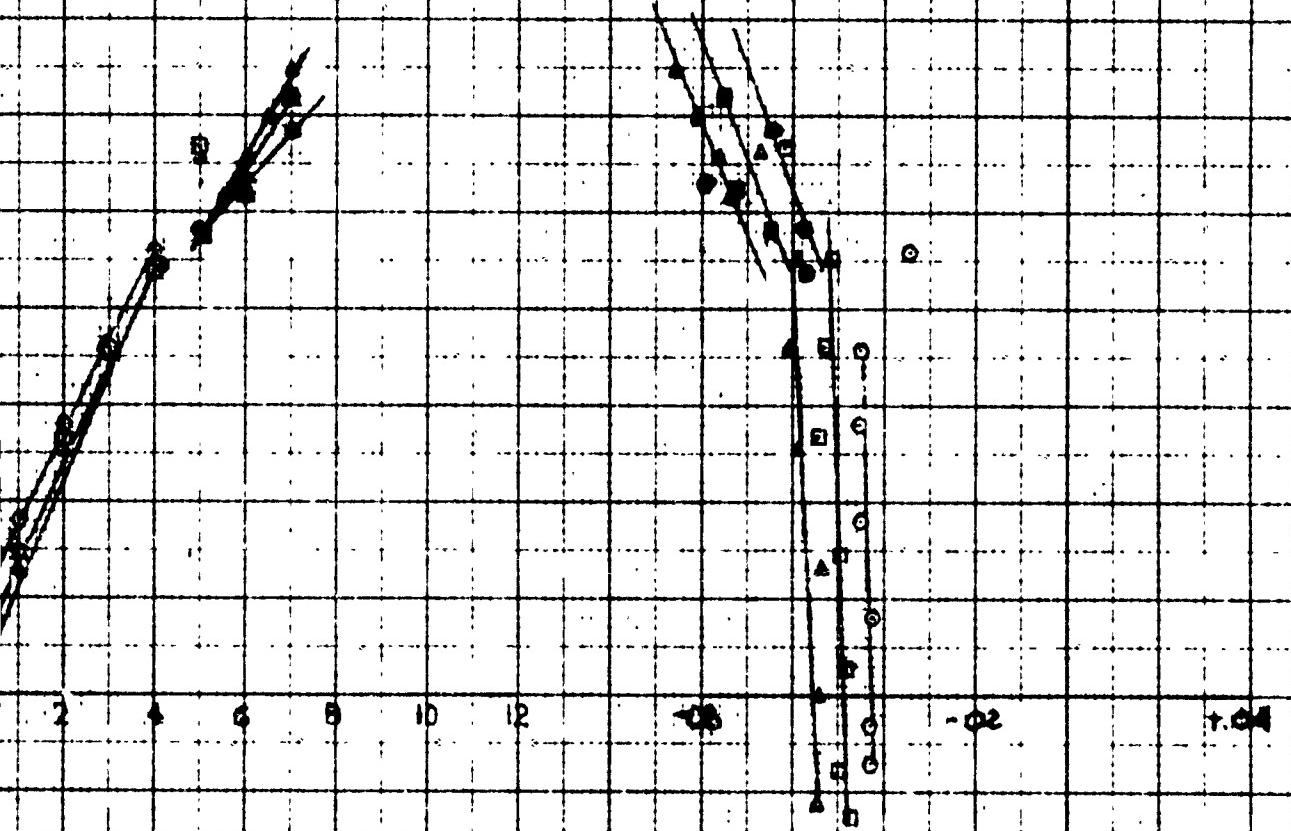
PAŃCZ IV. 20

WHEELING BANK TESTING

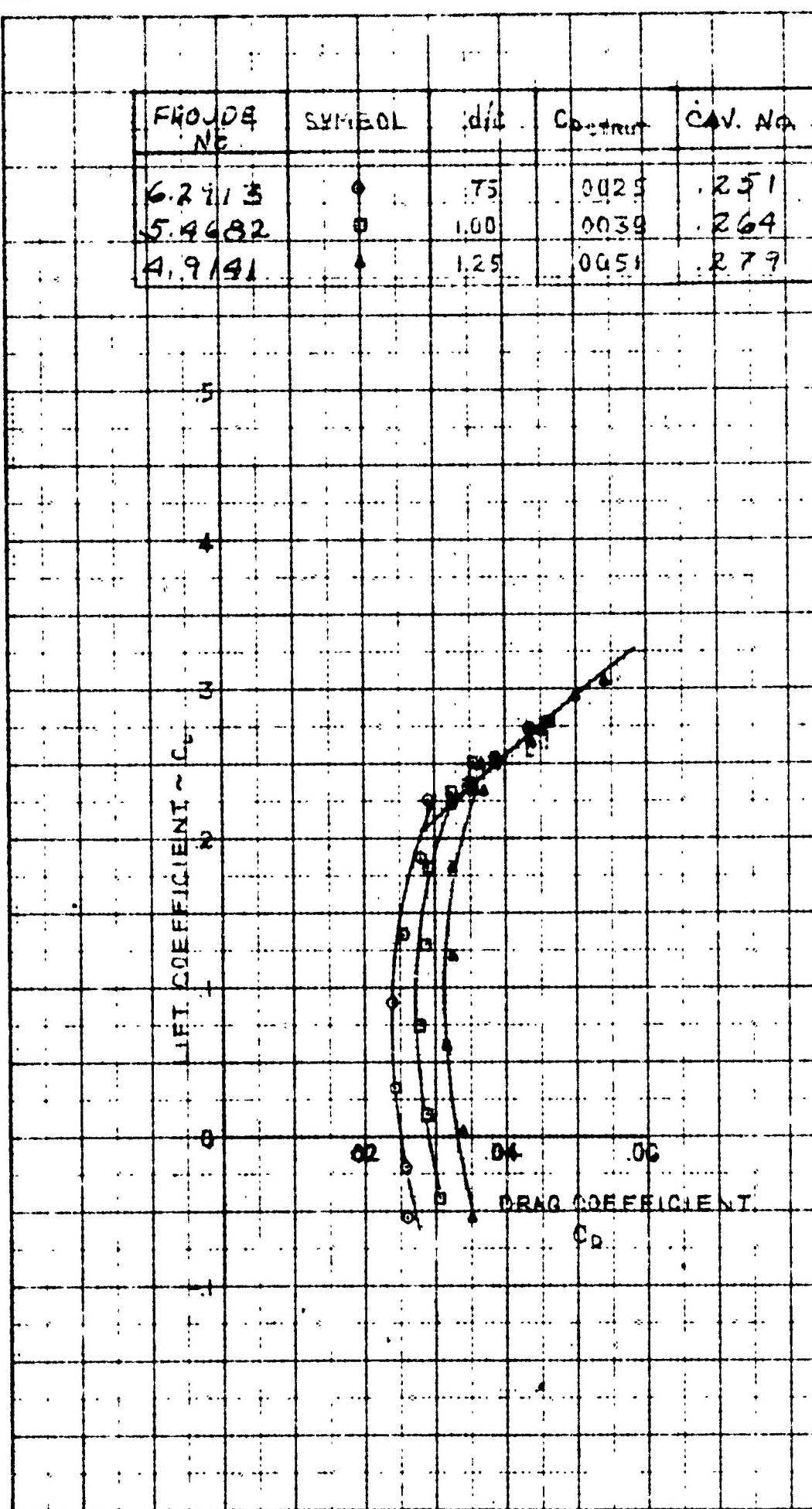
POLARIS FS NO 4.

SOKIS

124.5.9.144.51



ATTACK = α = DEGREES . . . PITCHING MOMENT COEFF $C_{M,\alpha}$



GRUMMAN AIRCRAFT EN

PAGE IV.21

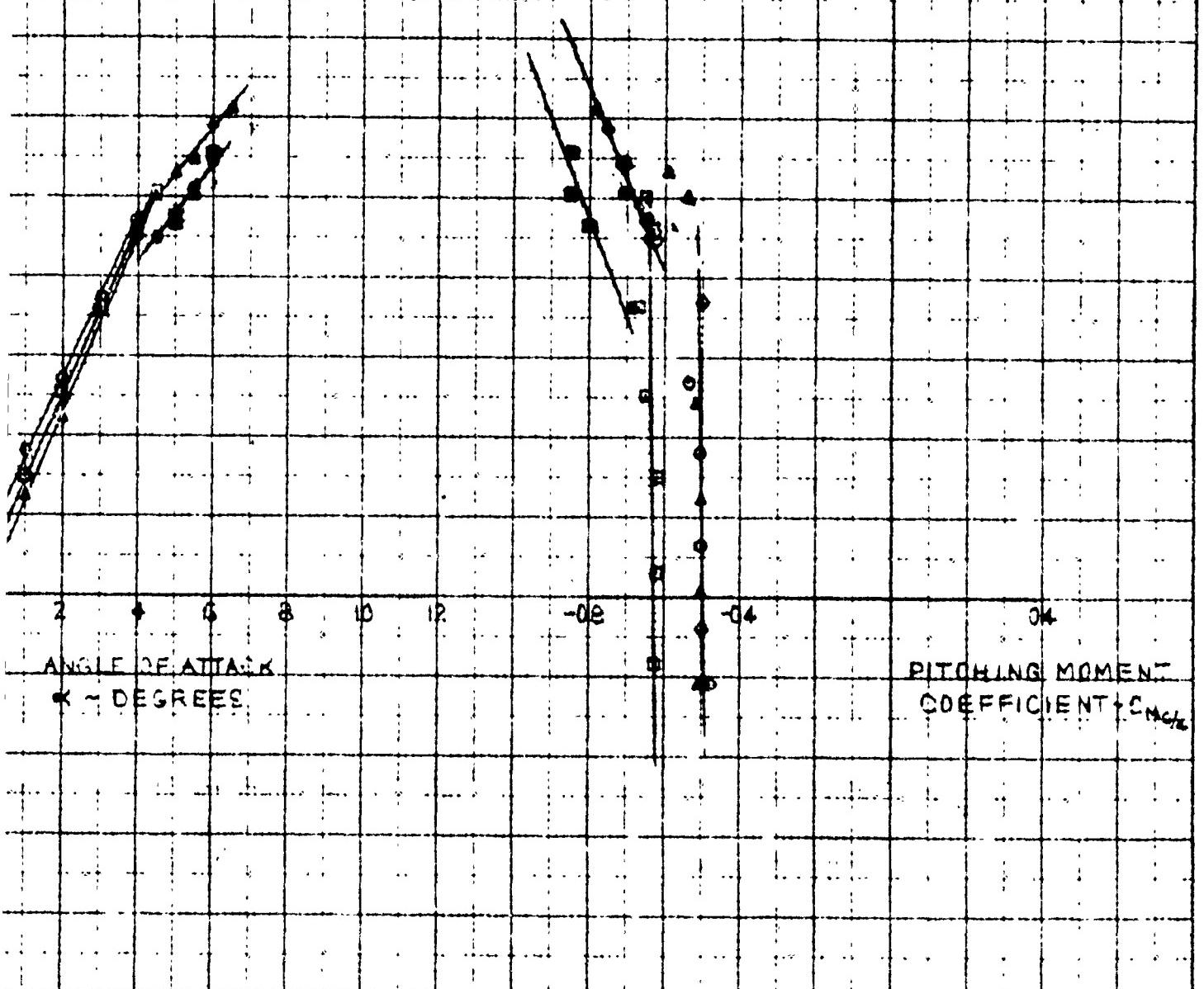
WHIRLING TANK TEST NO. 20G

BUSHIPS INC.

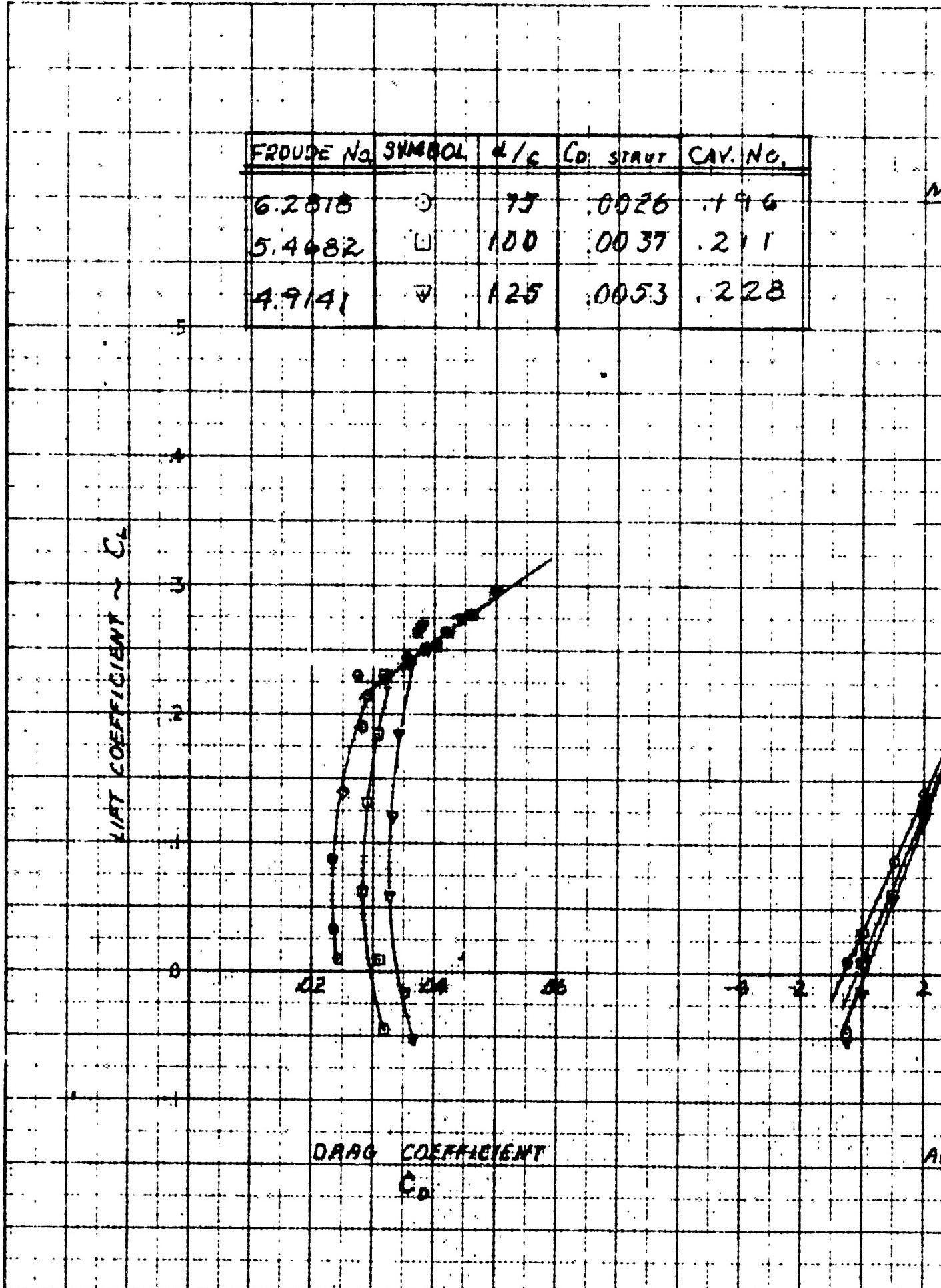
60 KTS

M.A.C. ± 144 FT.

NOTE:
1. DARKENED SYMBOLS INDICATE
VENTED FLOW



REPORT NO.



GRUMMAN AIRCRAFT ENGINE

PAGE IV.22

WHIRLING TANK TEST NO. 206

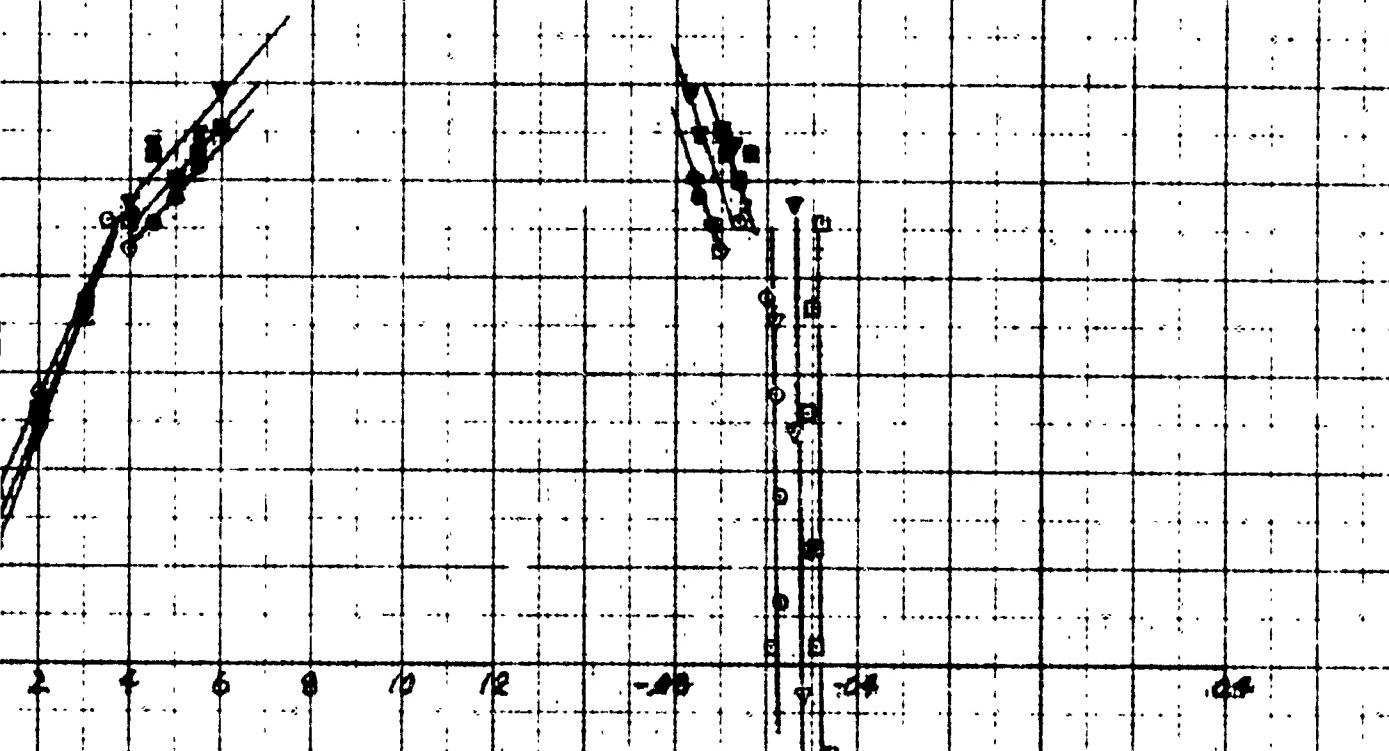
BU SHIPS NO. 4

70 MTS.

M.A.C. 3.144 FT

NOTE:

1. DARKENED SYMBOLS INDICATE
VENTED FLOW.



ANGLE OF ATTACK
 α - DEGREES

PITCHING MOMENT
COEFFICIENT ~ $C_M \alpha$

REPORT NO

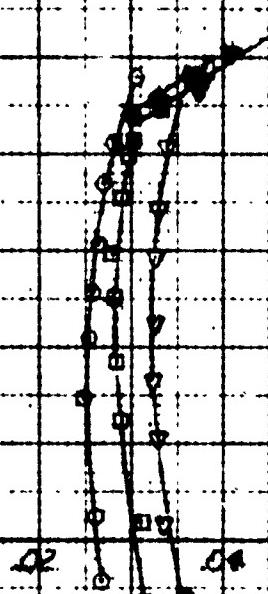
FROUDE No SYMBOL 4/5 C_D START CAV No.

6.2018 0 75 0026 .172

5.4482 □ 100 0039 .189

4.9441 △ 125 0055 .240

AIR COEFFICIENT - C_L



DRAG COEFFICIENT

C_D

PAGE IV.25

WHIRLING TANK TEST NO. 20G

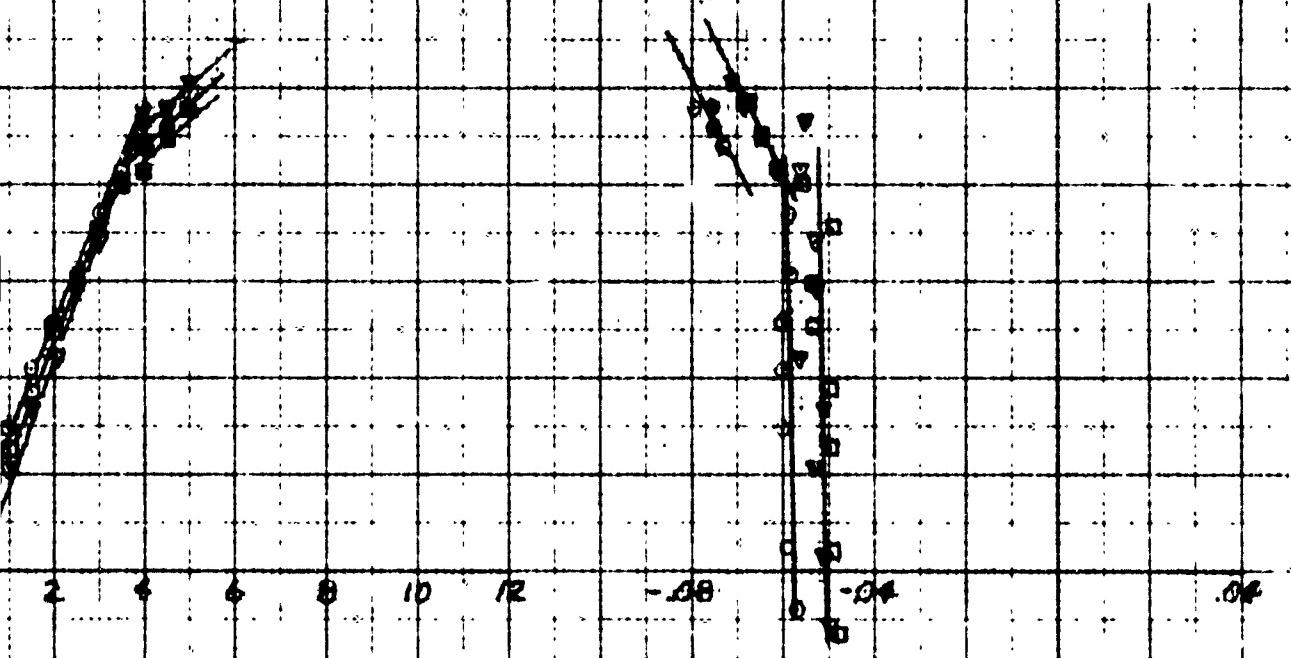
BU SHIPS NO. 4

BO KTS

NOTE:

1. DARKENED SYMBOLS INDICATE
VENTED FLOW.

MAC = 144 FT



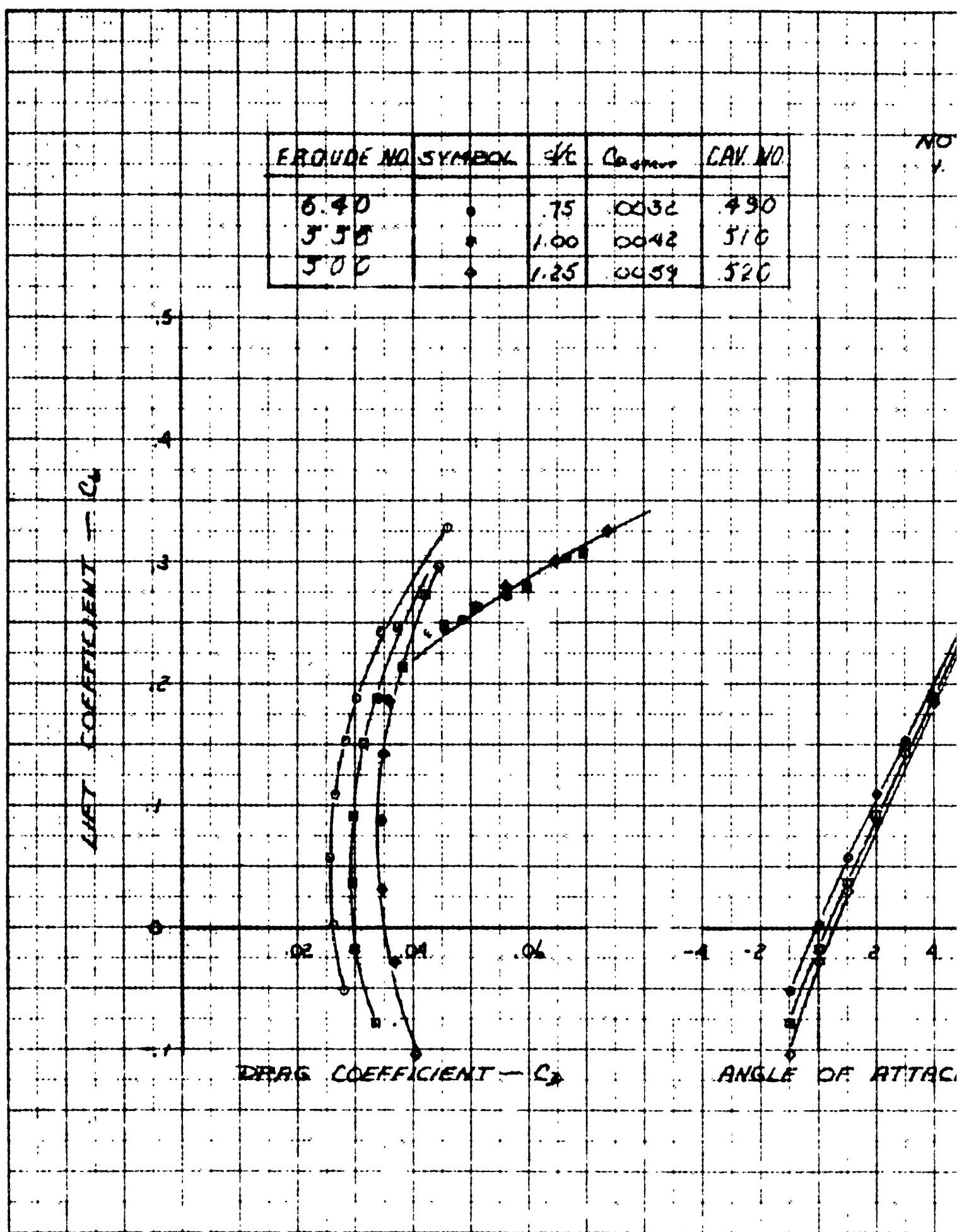
ANGLE OF ATTACK

CL - ATTACH

PITCHING MOMENT

COEFFICIENT ~ $C_{M,C}$

REPORT NO



PAGE III 24

WHIRLING TANK TEST NO 202

NO 48 81959

MODEL NO 5

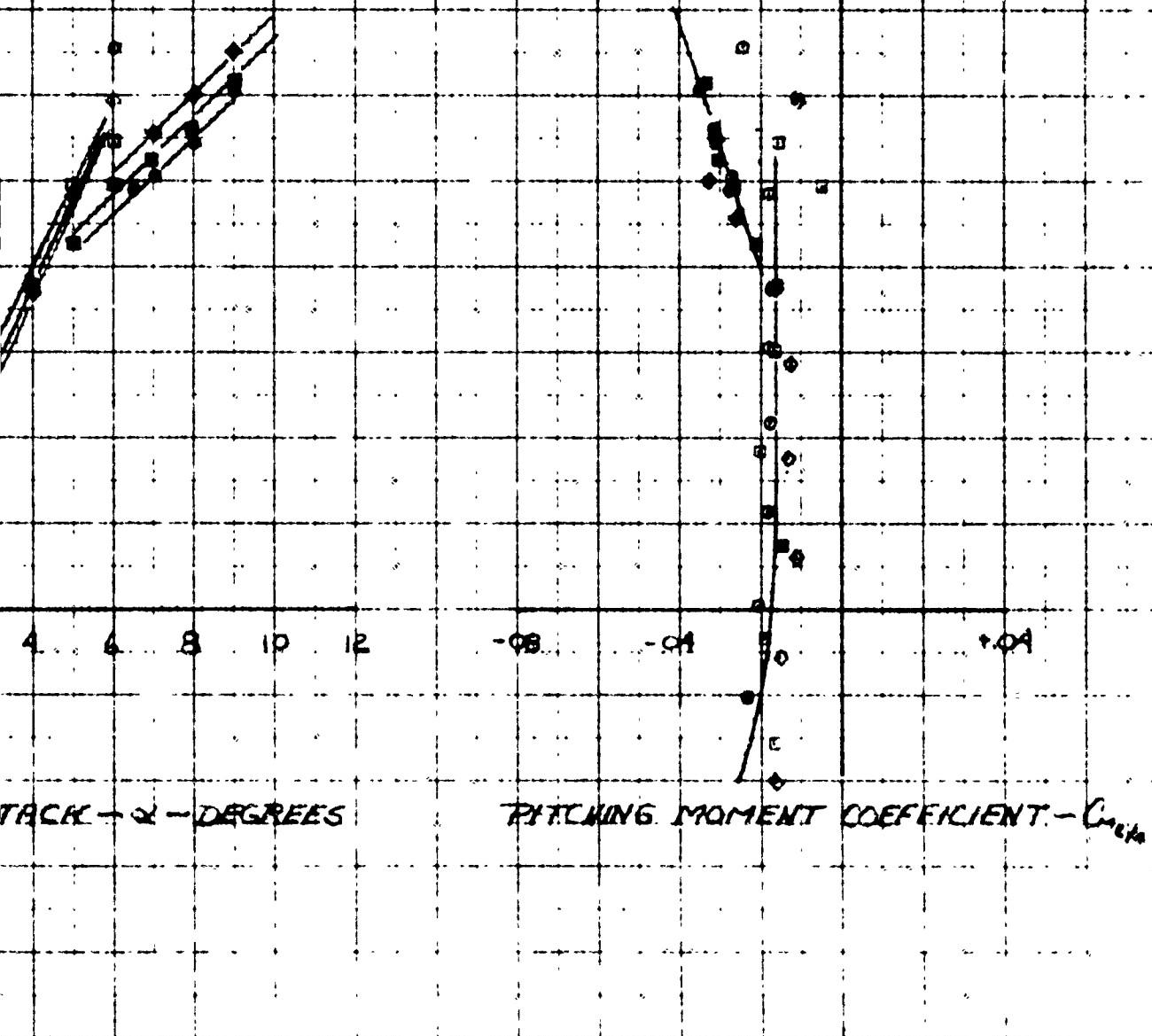
40 KTS

M.H.C. = 17.5 FT.

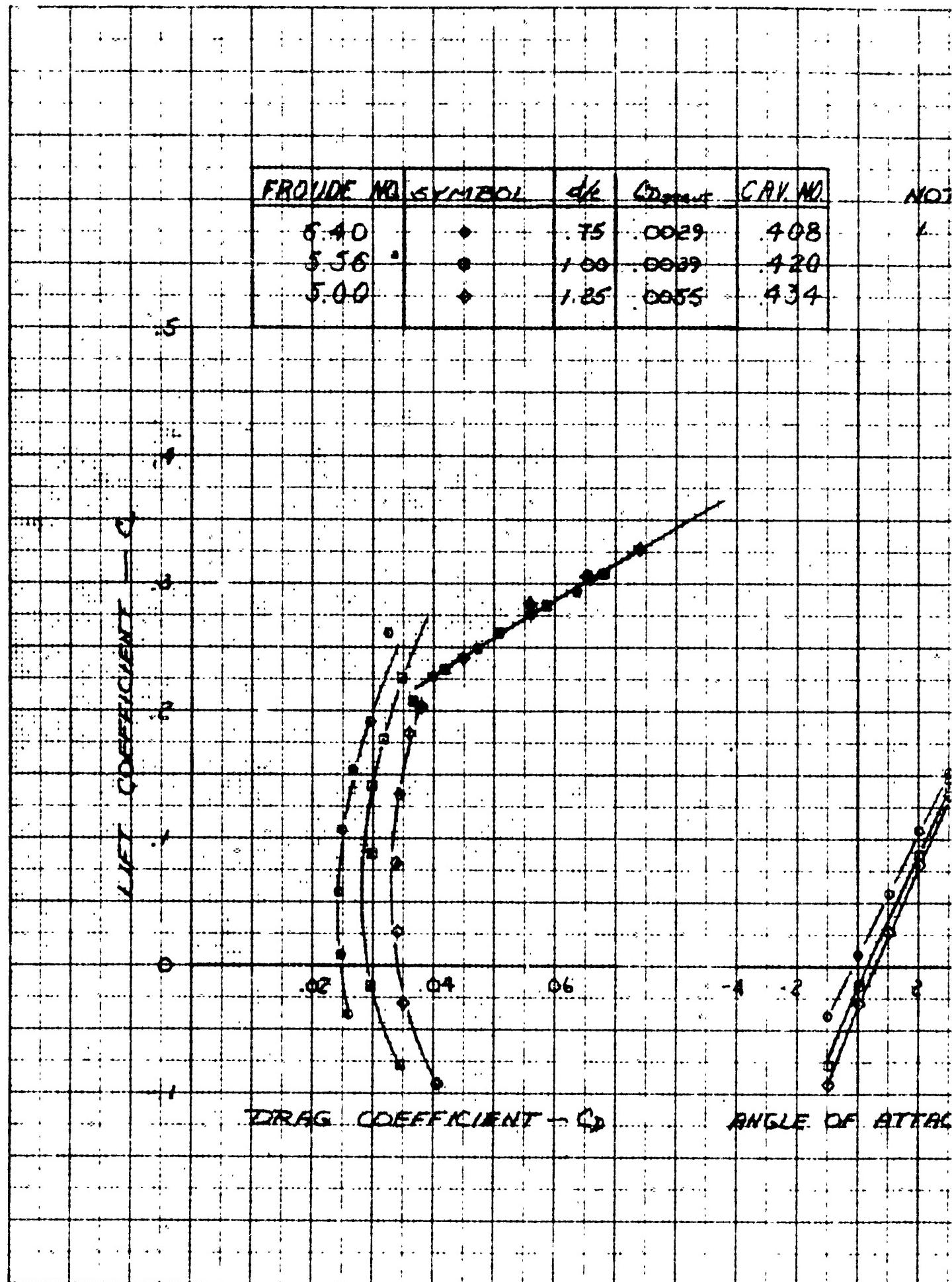
NOTE

DARKENED SYMBOLS
INDICATE VENTED FLOW

3X



KE 1000000000



PAGE III.25

WHIRLING TANK TEST NO. 628

NO 6s 84454

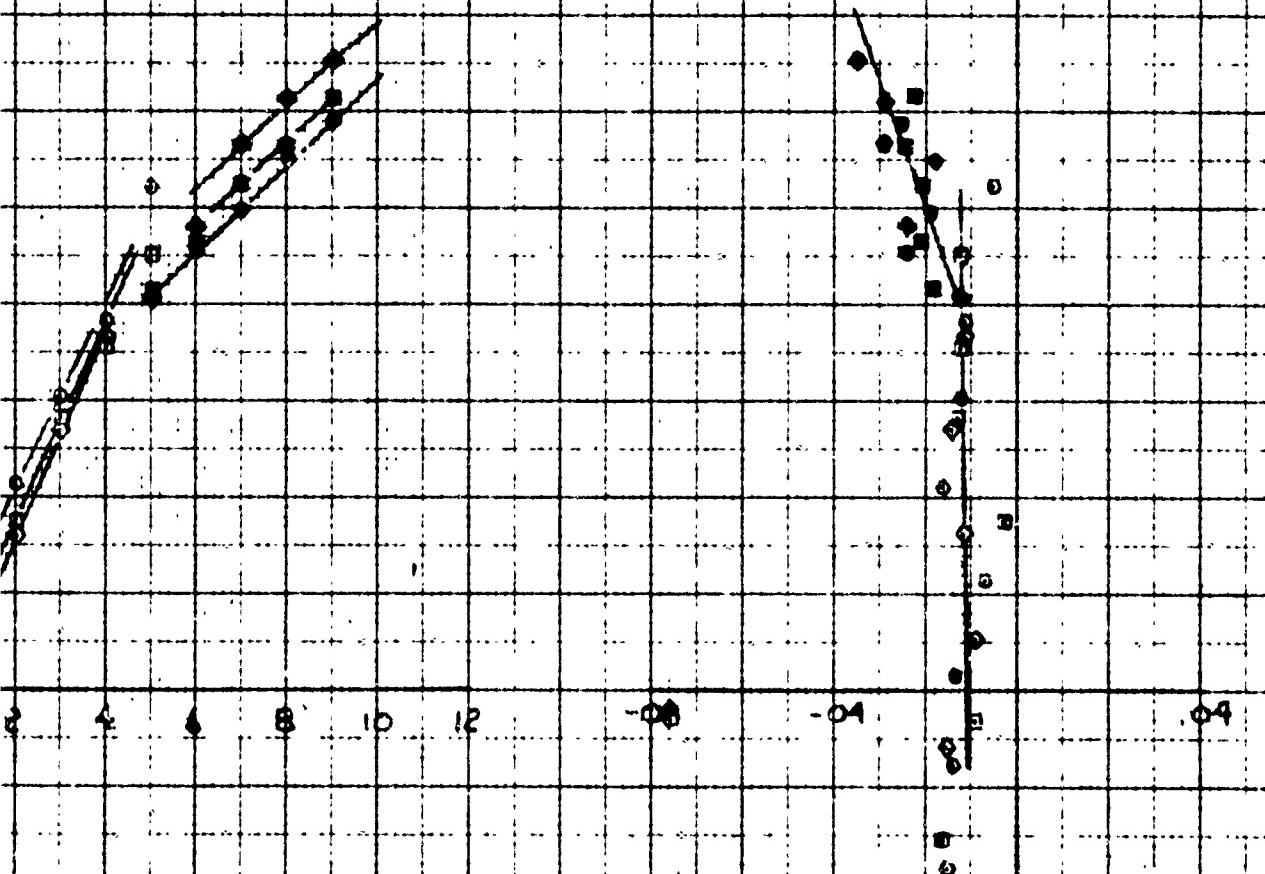
MODEL NO 5

95 KTS

M.B.T. = 137 FT

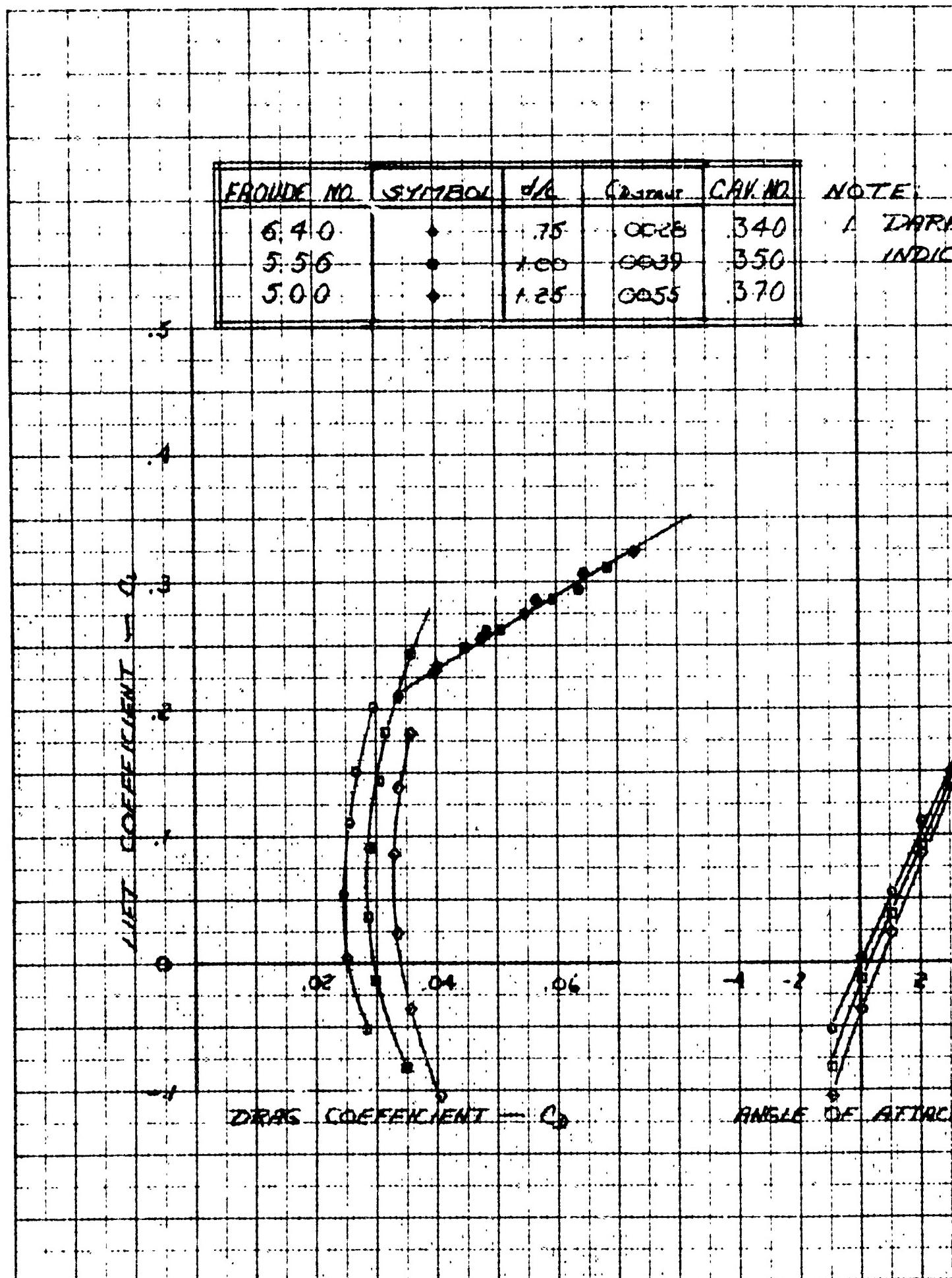
NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW



TRACK - DEGREES

TWISTING MOMENT COEFFICIENT - C_{M4}



WHIRLING TANK TEST NO 208

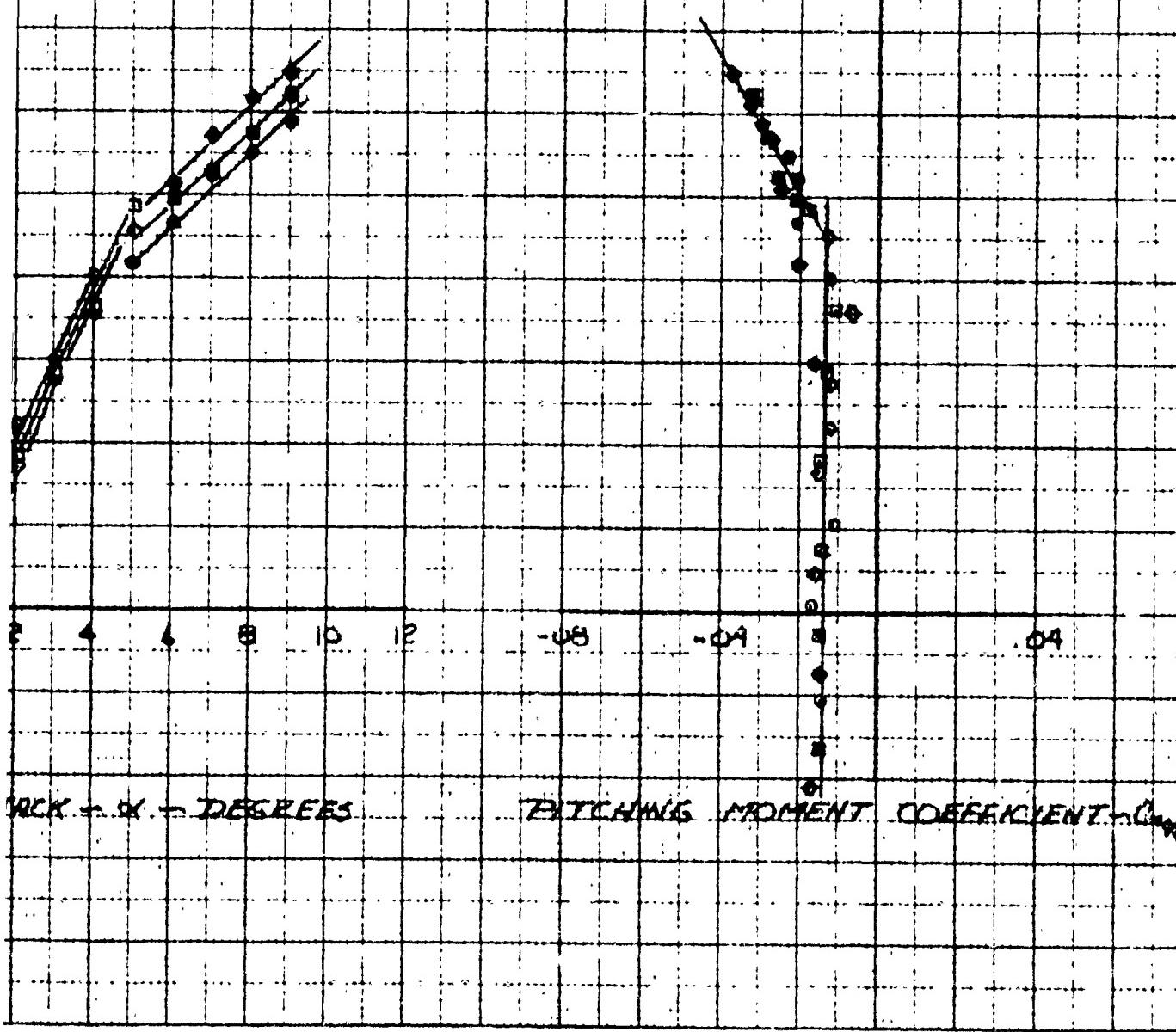
NO 63 84454

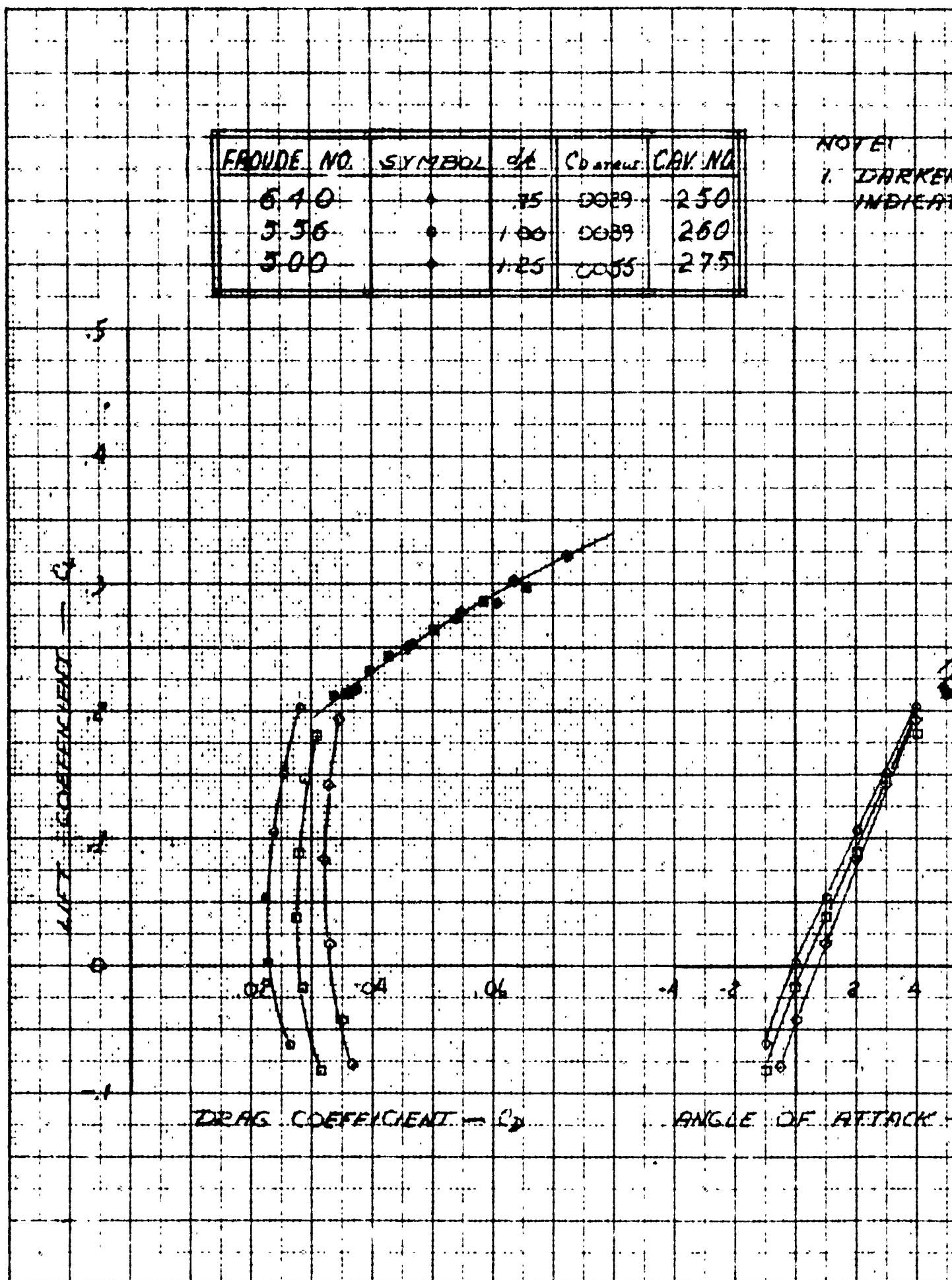
MODEL NO 5

50 KTS

W.B.L. = 37 FT

MARKED POINTS
INDICATE VENTED FLOW





GRUMMAN AIRCRAFT ENGINEER

PAGE II.67

WHIRLING TANK TEST NO 208.

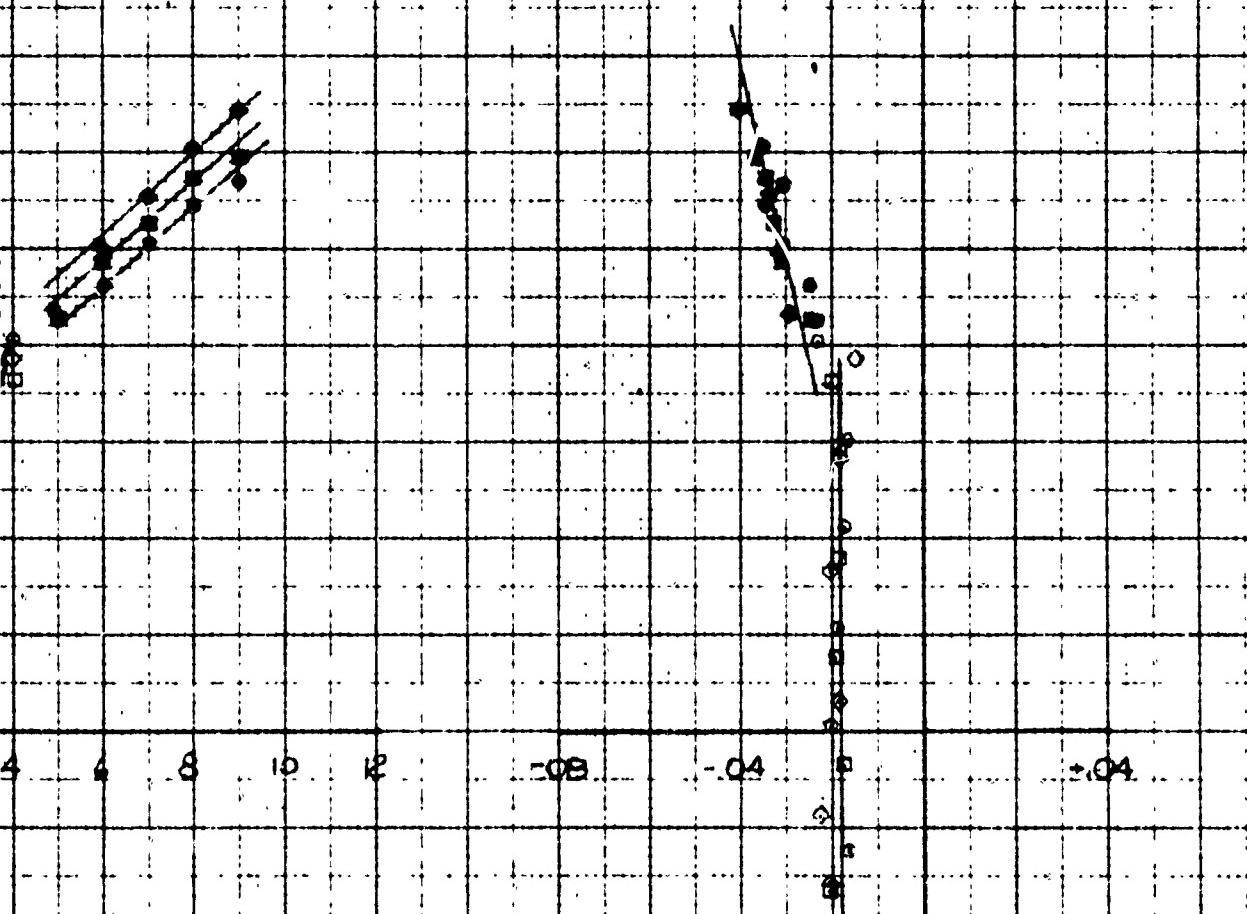
NU 63 89454

MODEL NO 5

60 KTS

MACH = 1.37 FT.

REMOVED SYMBOLS
CREATE VENTED FLOW



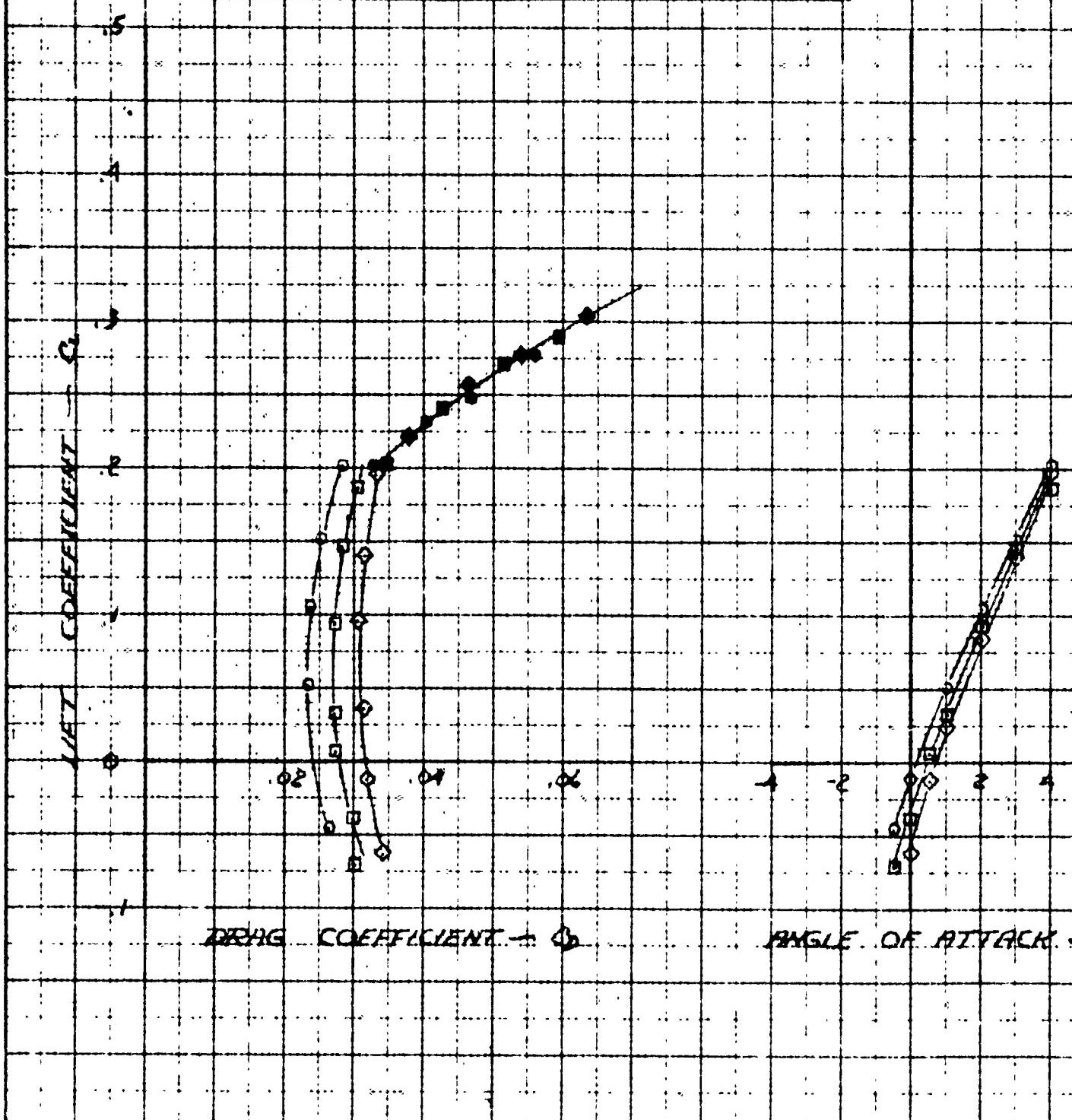
α - ANGLE OF ATTACK

PITCHING MOMENT COEFFICIENT - C_m

REPORT NO.

FRAC N.D.	CAN NO.	SIMBOL	1/2	Carries
6 4 0	196	+	.75	.0030
5 5 6	210	+	1.00	.0041
5 0 0	225	+	1.25	.0059

NGTE:



GRUMMAN AIRCRAFT ENGINE

PAGE IV 15

WHIRLING TANK TEST NO. 808

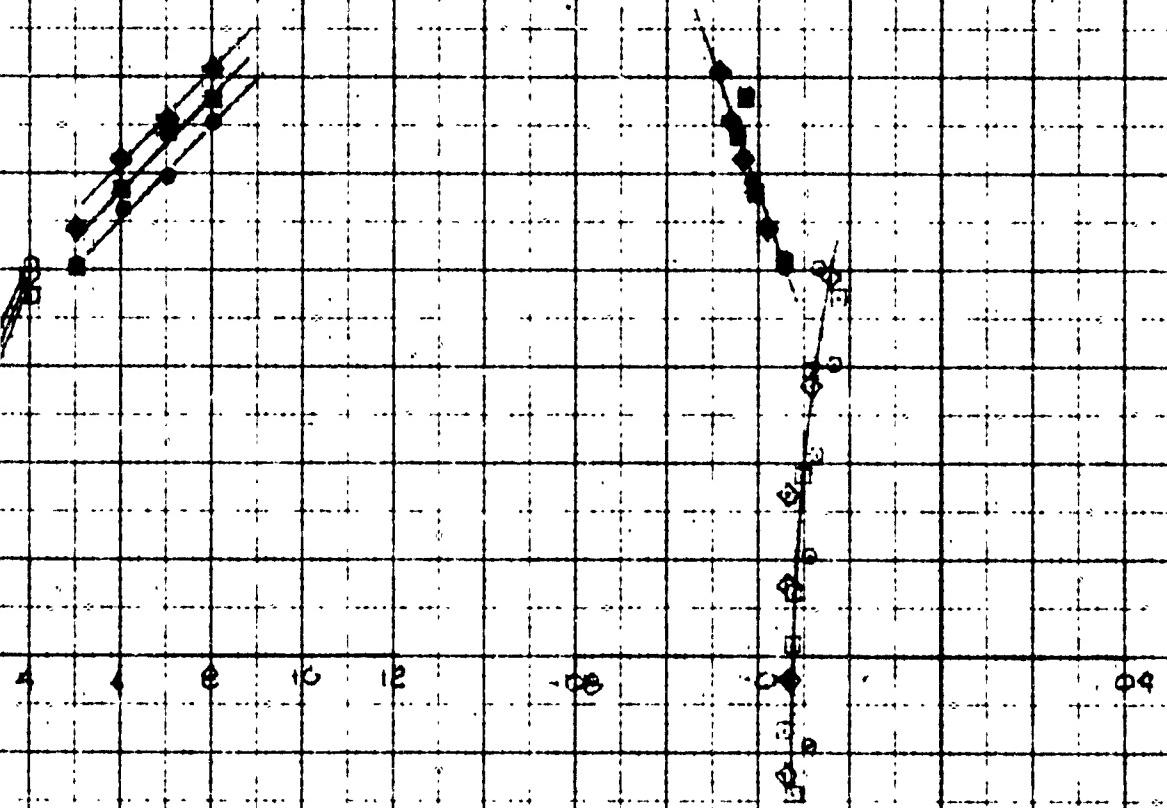
NO G- 84454

MODEL NO. 5

7.0 KTS.

A.H.C. = 139 FT

TE:
DARKENED SYMBOLS
INDICATE VENTED FLOW



DEGREES

PITCHING MOMENT COEFFICIENT

REPORT NO

FREQUENCY NO.	SYMBOL	α	Coeff.	CAV. NO.
6.40		.75	0032	175
5.56		1.00	0040	189
5.00		1.25	0036	203

NOTE:
1. DARK
INDICA

CL_A - COEFFICIENT

Drag Coefficient - C_D

ANGLE OF ATTACK

GRUMMAN AIRCRAFT ENGINE

PAGE IV

WHIRLING TANK TEST NO. 20

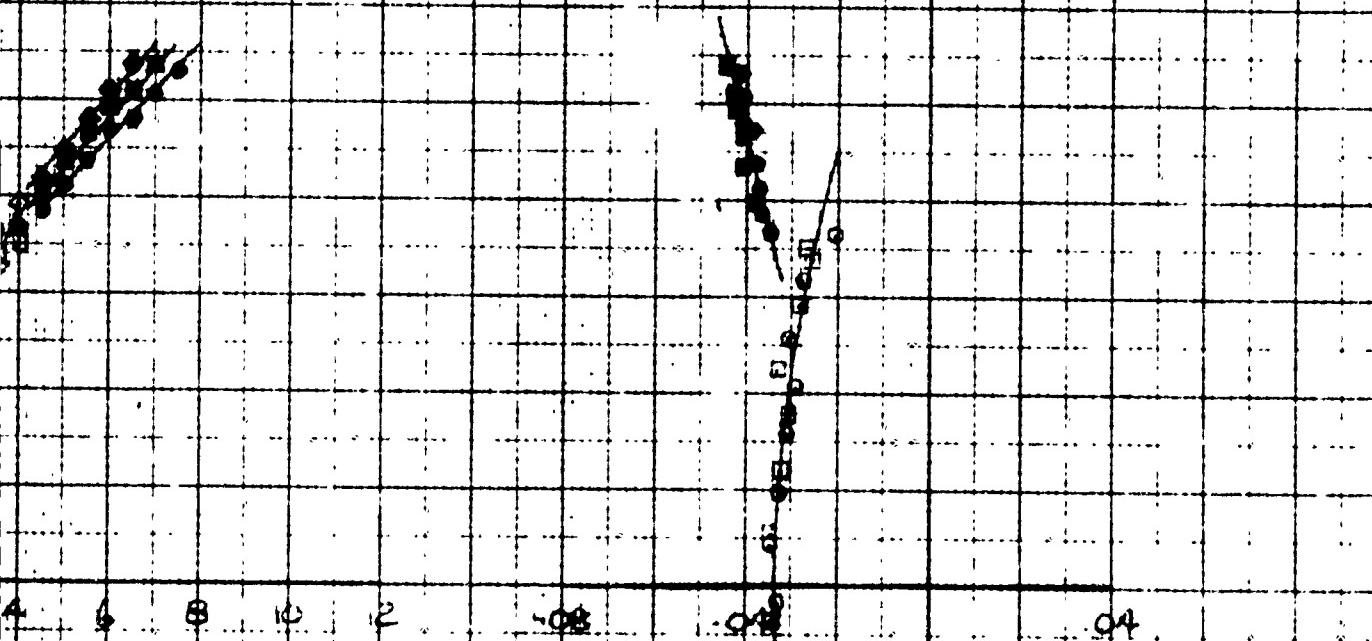
NO. 62 84851

MODEL NO. 5

500 KTS

$A_{10} = 1.3 \times 10^6$

RAISED SYMBOLS
INDICATE VENTED FLOW



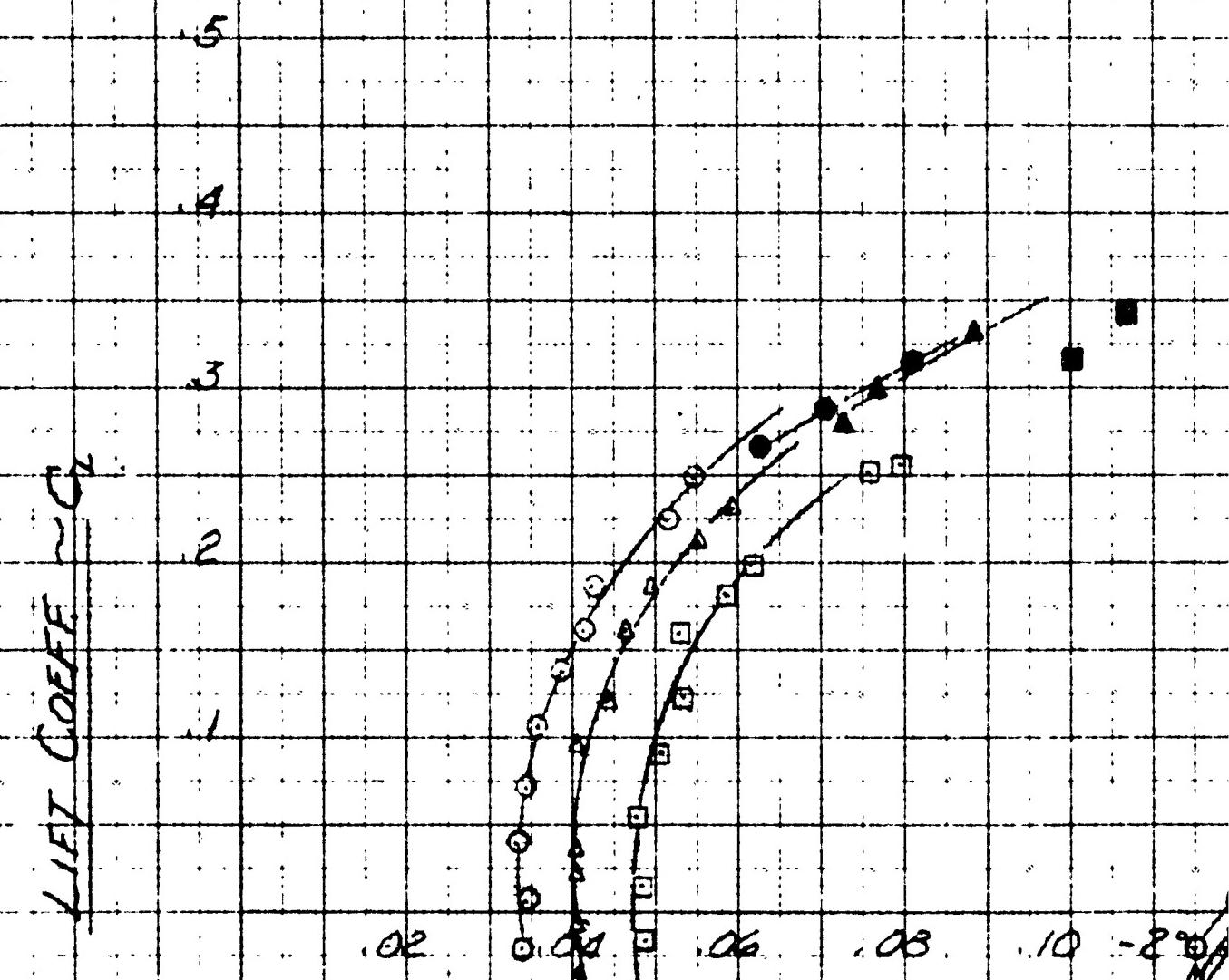
ANGLE OF ATTACK - DEGREES

PITCHING MOMENT COEFFICIENT - C_m

REPORT NO.

FROUDUE NO	CAY. NO	SYMBOL	%	C_d STOUT
4.8189	.528	○	0.75	0.038
4.2032	.553	▲	1.00	0.069
3.7859	.585	□	1.25	0.101

NOTE:
1. DARK
1A



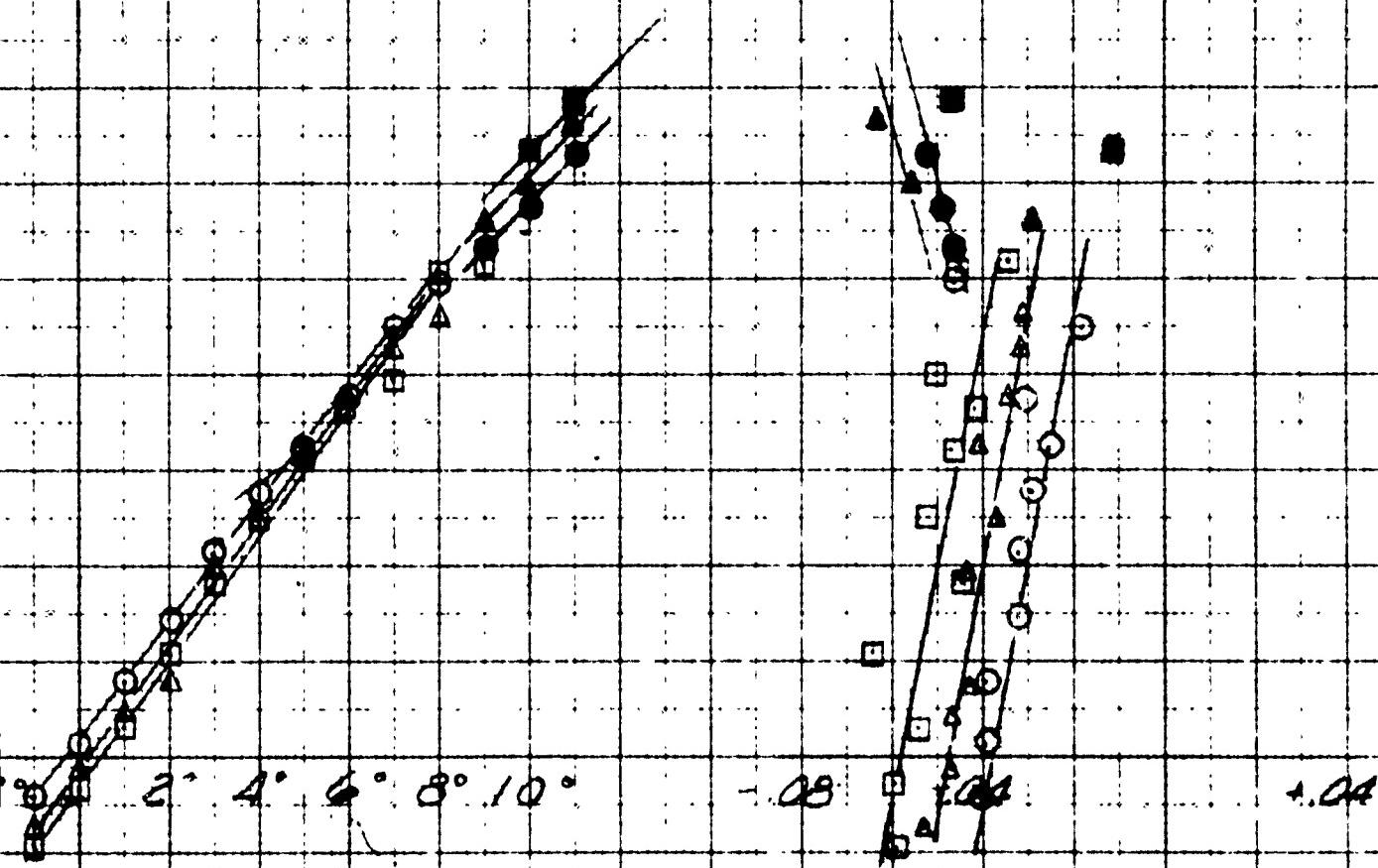
TOP COEFF →

WHIRLING TANK TEST NO 2QFBUSHIPS NO 6

40 KTS

MAC = 250 FT

MARKENED SYMBOLS
INDICATE VENTED
FLOW.

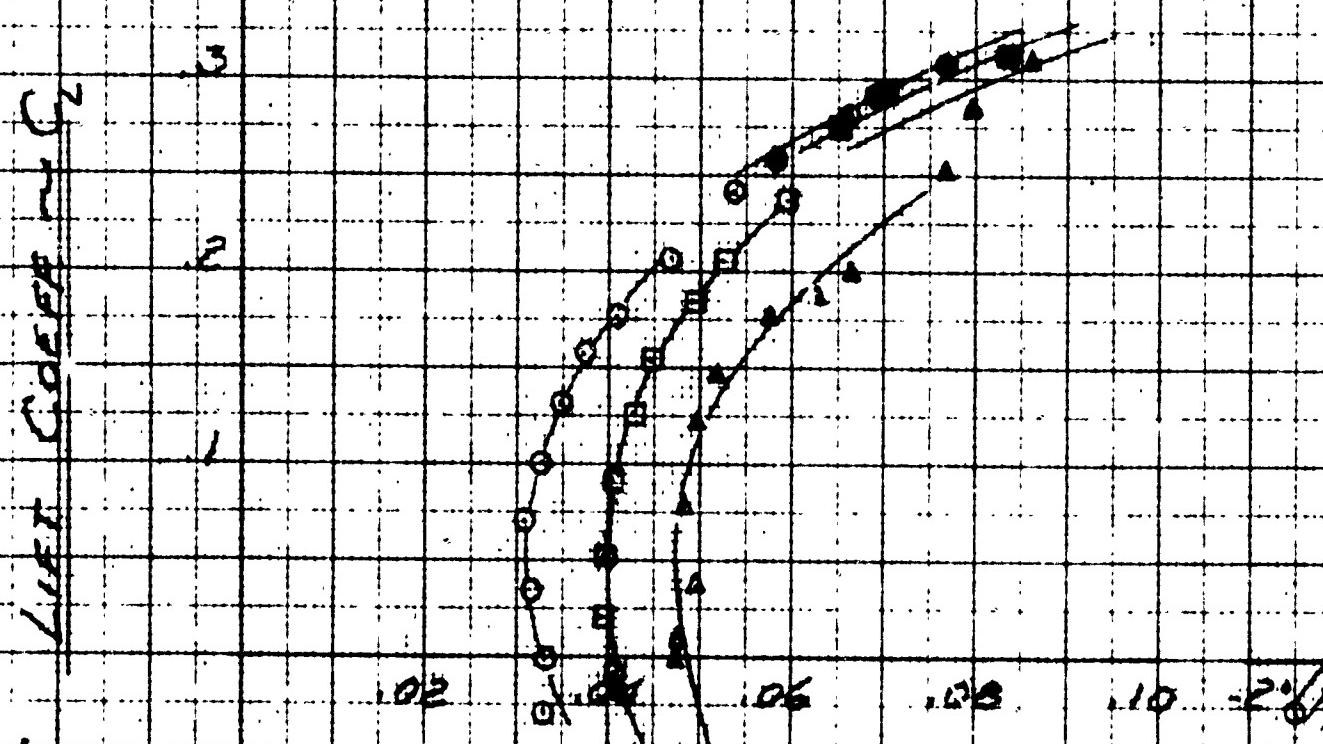


ANGLE OF ATTACK
 α + DEGREES

PITCHING MOM.
COEFF.
 M_q

FRAUDE NO CAN. NO 5 SYMBOL % C_D STRUT

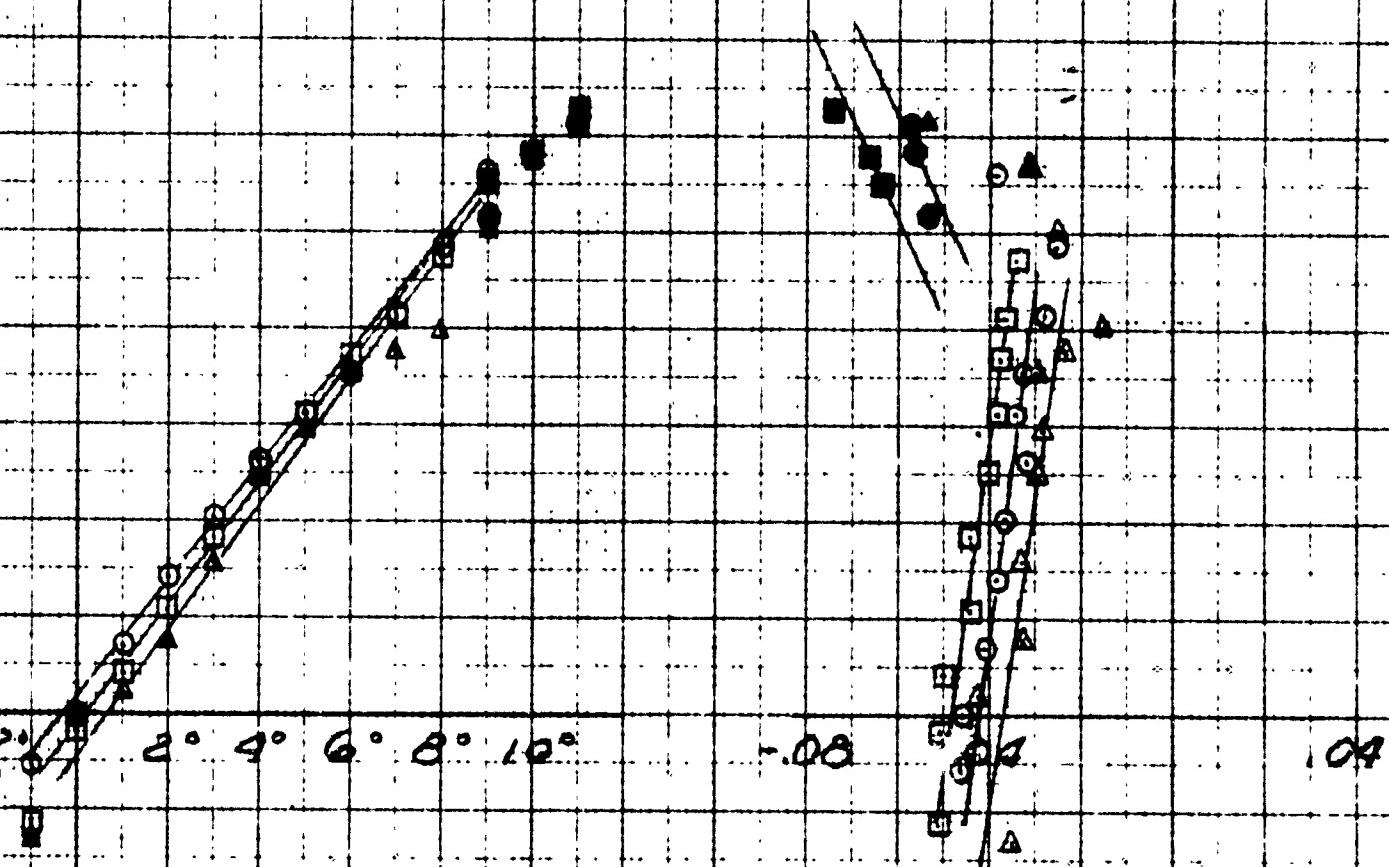
4.8189	.435	○	0.75	.0046	NOTE
4.2032	.458	■	1.00	.0072	I.D.
3.7859	.485	▲	1.25	.0103	



WHIRLING TANK TEST NO. 20F
BUSHIPS NO. 6

15 KTS

NOTE:
 DARKENED SYMBOLS
 INDICATE VENTED
FLOW.



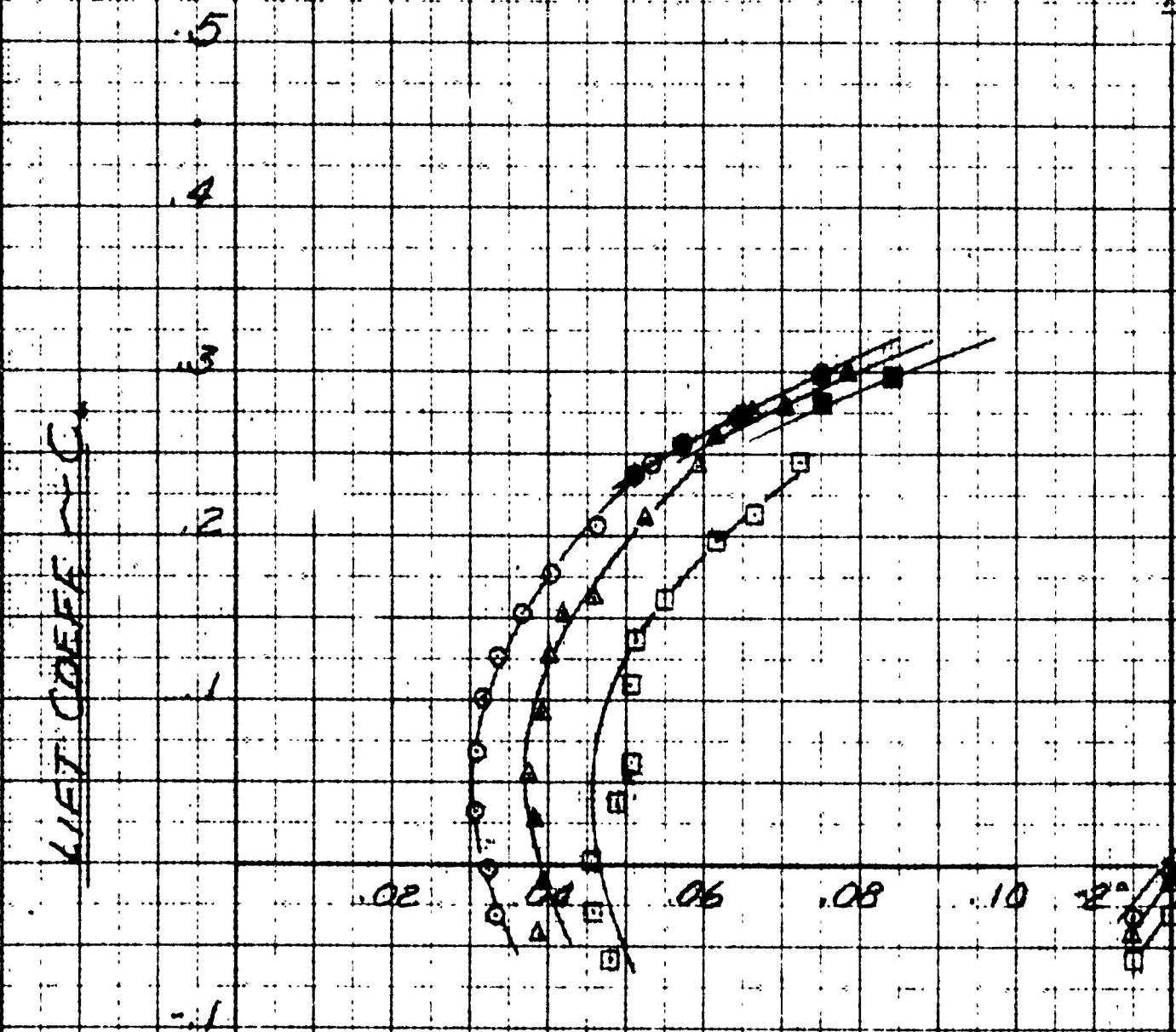
ANGLE OF ATTACK
 α ~ DEGREES

PITCHING MOM.
 COEFF. ~ C_{M_d}

FAIRING NO CAV No SYMBOL % C.D. STRUT

4.8189	.365	0	0.75	0049
4.2032	.395	▲	1.00	0074
3.70517	.420	■	1.25	0108

NOTE:
1. DARK
INDIC



DRAG COEFF ~ C_D

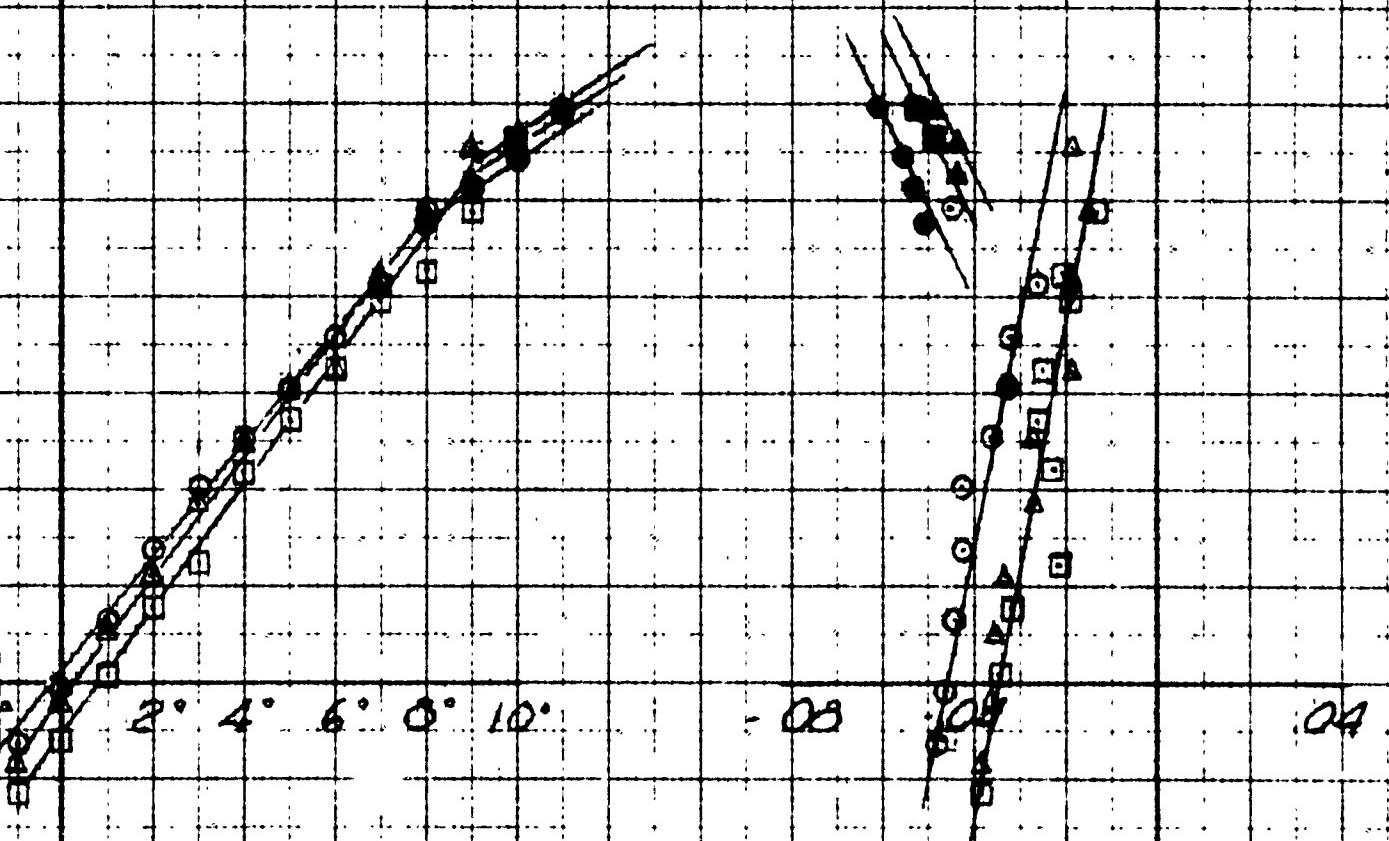
PAGE IV.32

WHIRLING TANK TEST NO. 20F
BUSHIES NO. 6

50 KTS.

MAC = 250 FT

OPENED SYMBOLS
INDICATE VENTED
FLOW.



ANGLE OF ATTACK
α - DEGREES

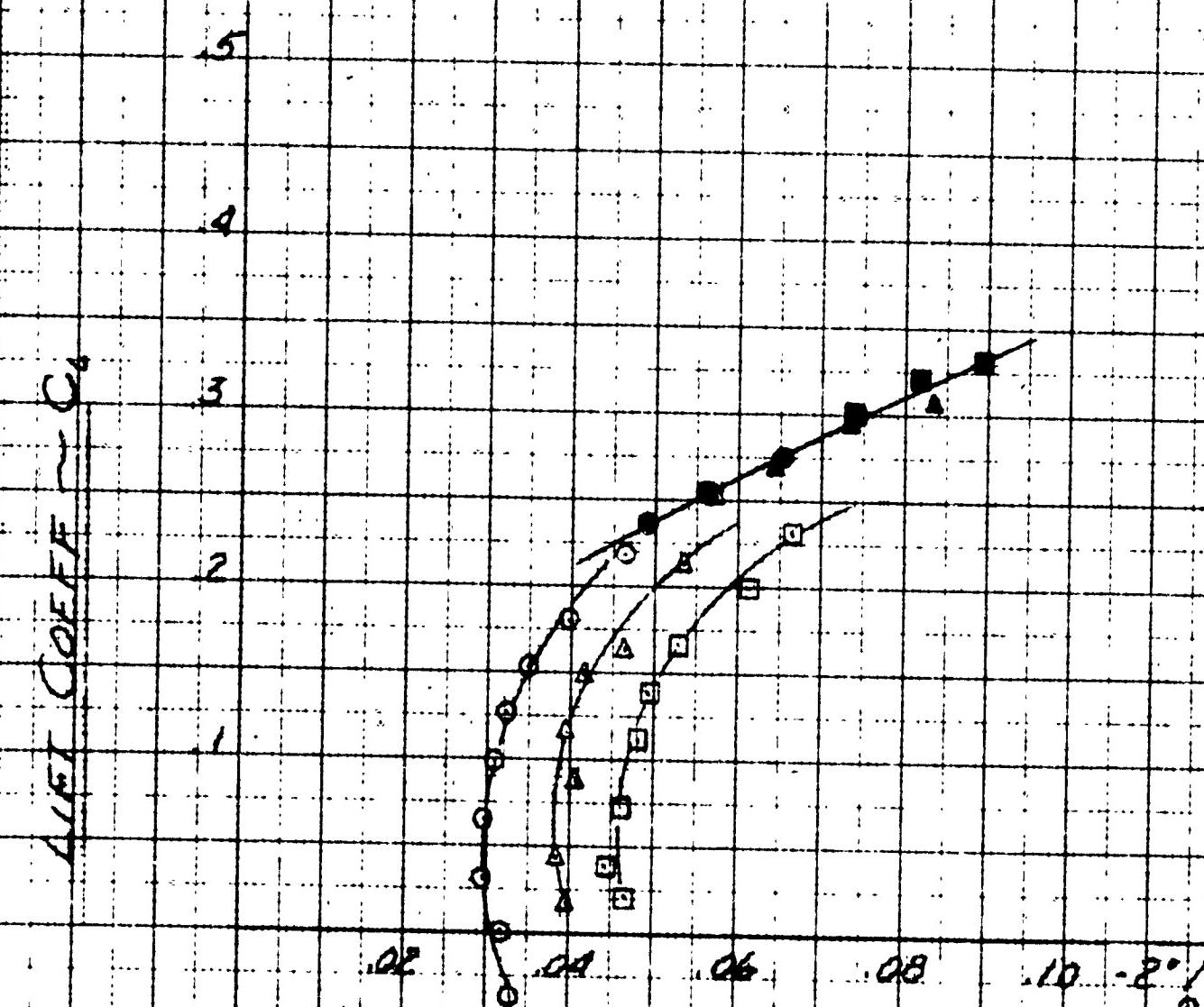
PITCHING MOM
COEFF - C_M

REPORT NO

EROWIE No. CIV. No. SYMBOL %C Cd STRUT

4.8189	.284	○	0.75	.0052
4.2032	.307	▲	1.00	.0078
3.7859	.356	□	1.25	.0112

NOTE:
1. DARK
IND

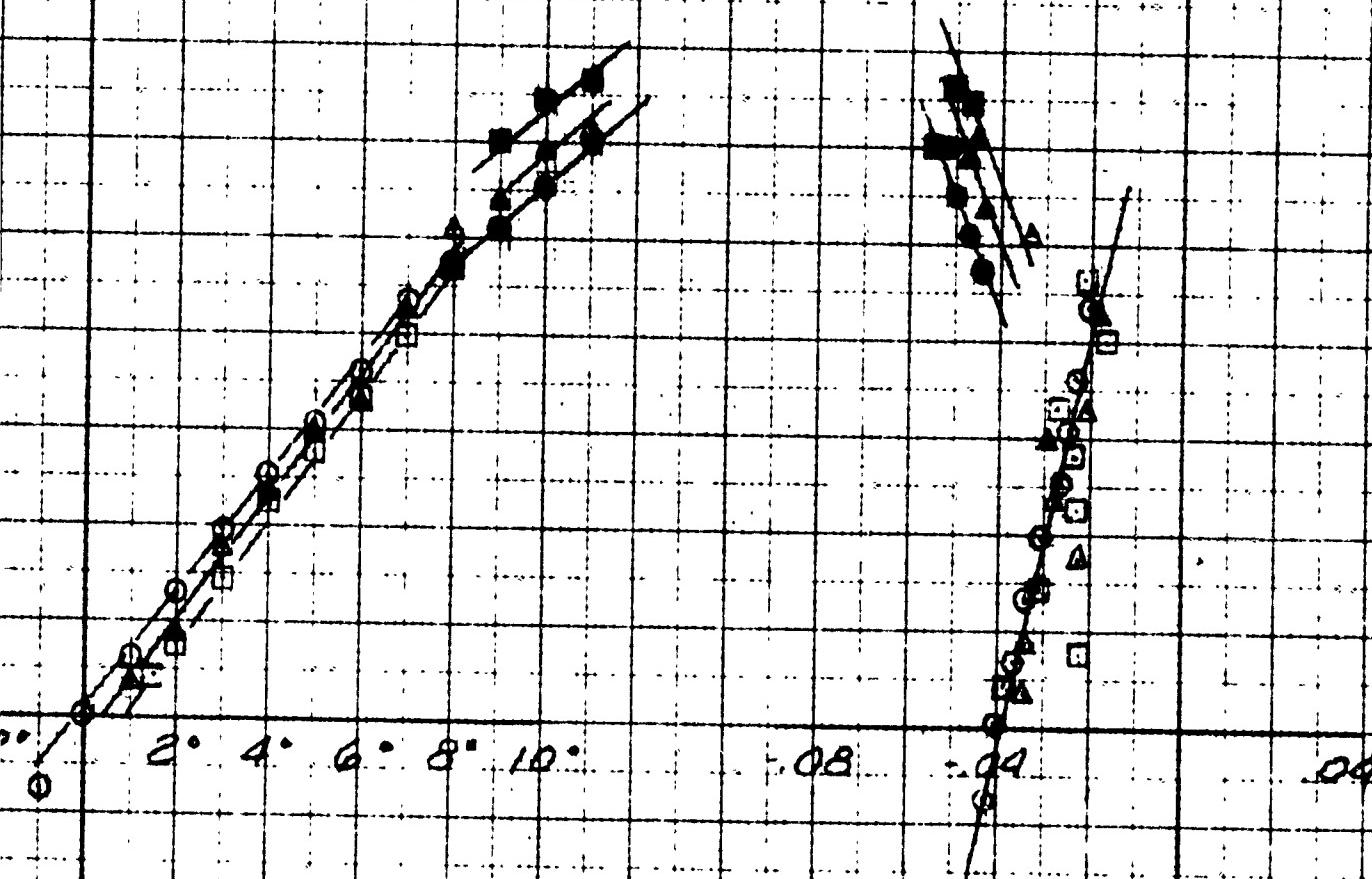


DRAG COFFEE - C

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WHIRLING TANK TEST NO. 20F
BU SHIPS NO. 6
60 KTS.

OPENED SYMBOLS
INDICATE VENTED
FLOW



ANGLE OF ATTACK
° - DEGREES

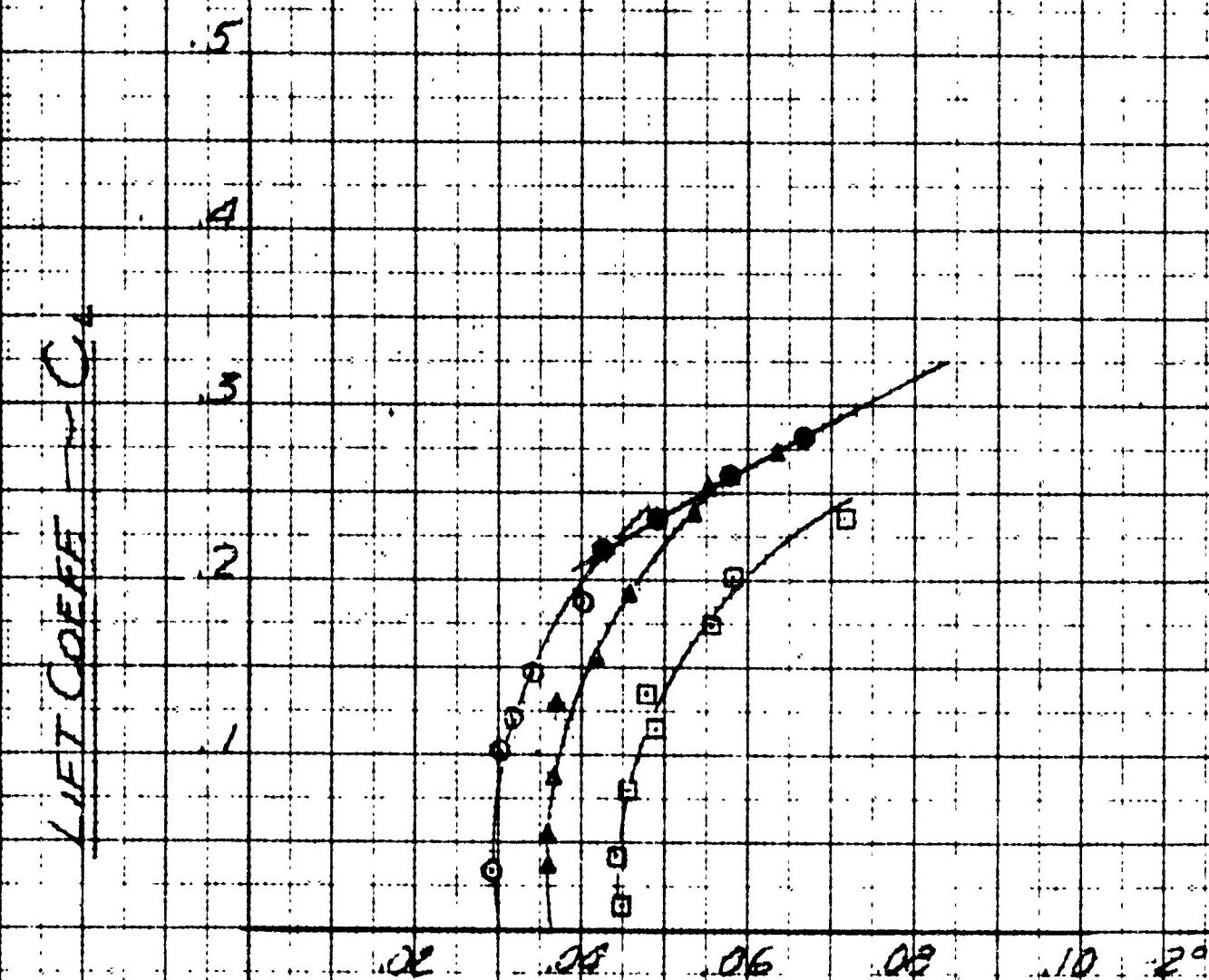
DITCHING MOM
COEFF ~ C_M

REPORT NO

FRONDE No	CIV. No	S Y M B O L	% C	Ca S T R U C T
48188	231	o	0.75	.0054
42032	252	▲	1.00	.0076
37859	279	o	1.25	.0113

NOTE

1104

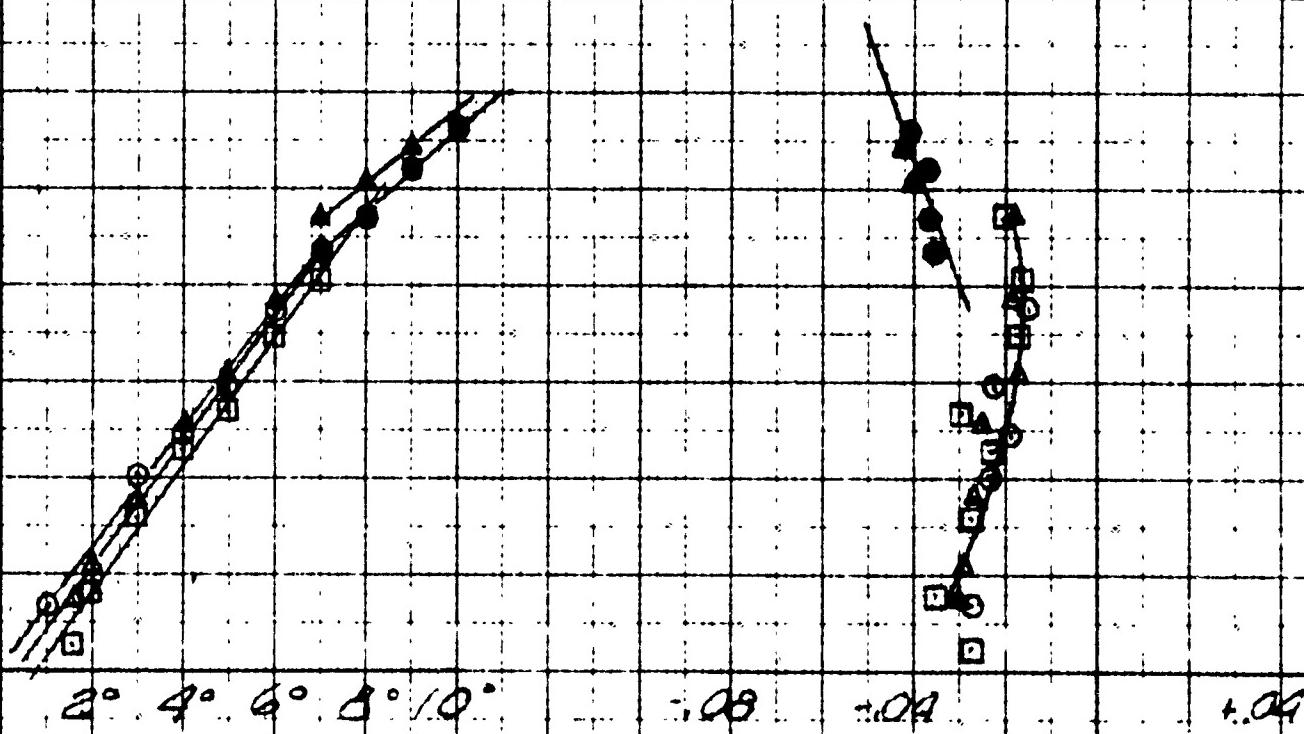


DRAG COEFF - C_D

PAGE IV.34

WHIRLING TANK TEST NO 20F
BUSHIPS NO. 6
70 KTS

TE:
DARKENED SYMBOLS
INDICATE VENTED
FLOW.



ANGLE OF ATTACK
° = DEGREES

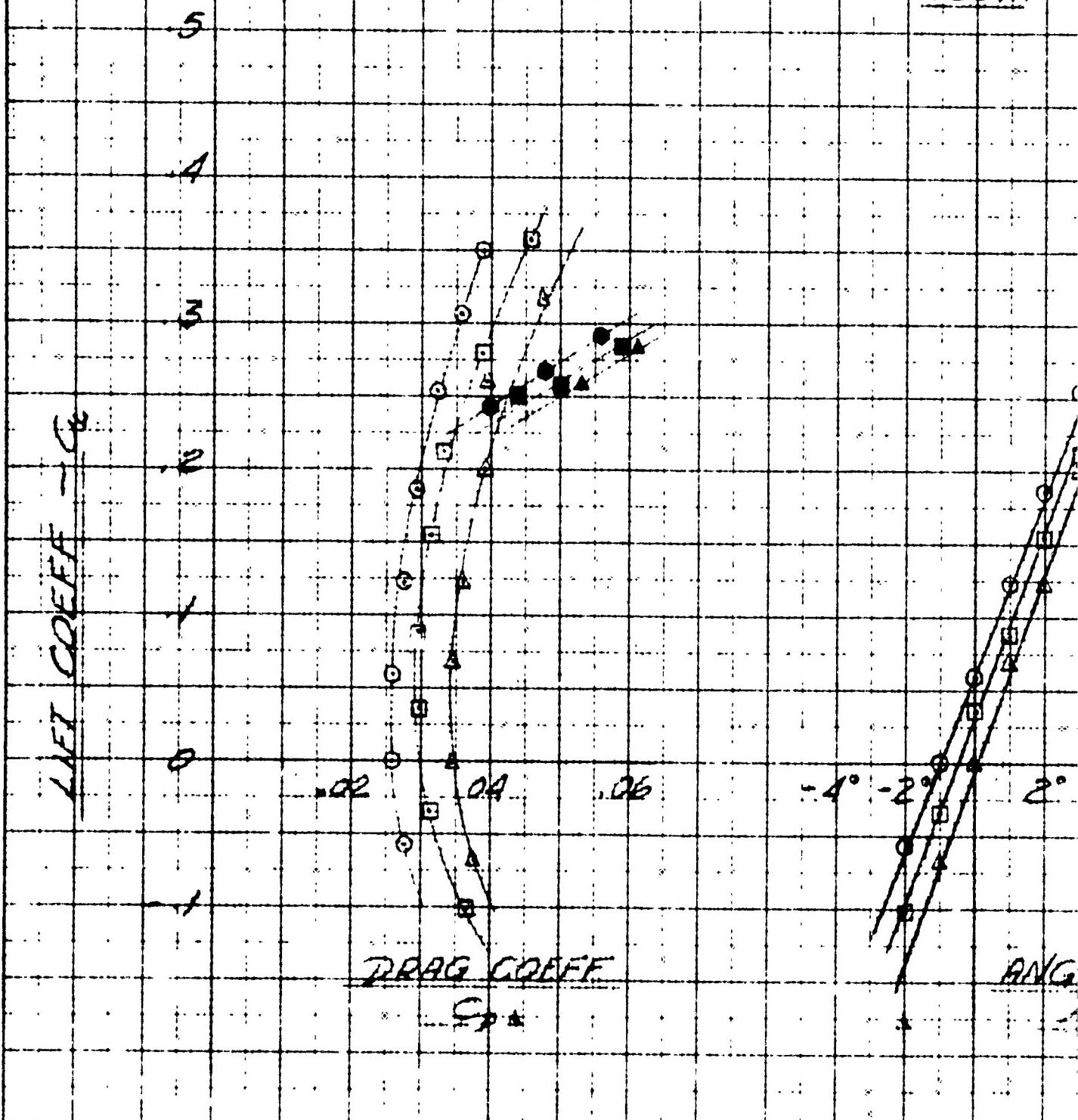
DITCHING MOM.
COEFF = C_m

REPORT NO

FREOUDE No	CHV. No.	SYMBOL	d/c
5.2260	478	○	.75
7.1414	483	□	1.00
6.4531	489	▲	1.25

NOTE:

DARKENED S
INDICATE YE
FLOW.



GRUMMAN AIRCRAFT ENGINE

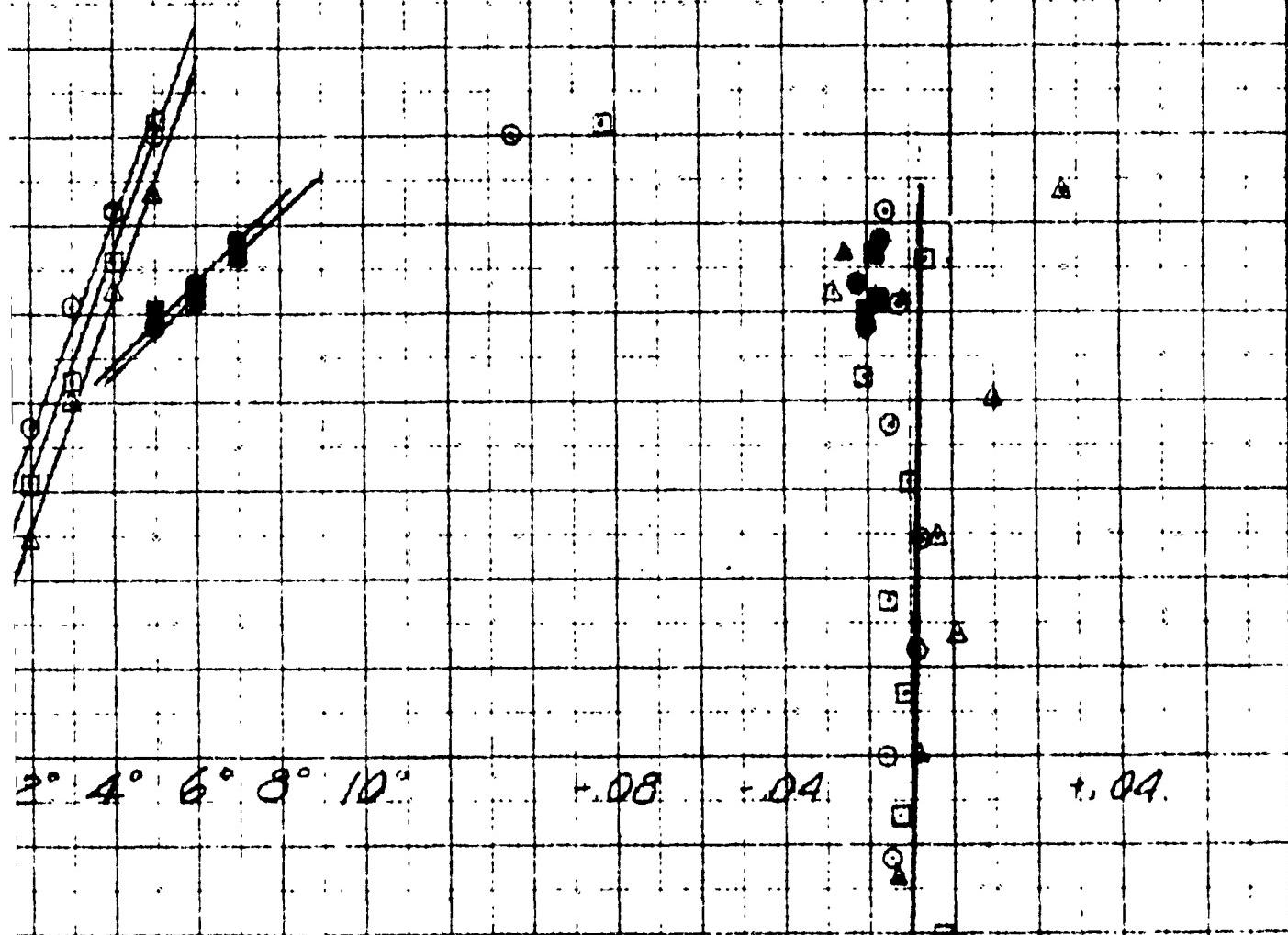
PAGE IV.35

WHIRLING TUNS TEST NO. 202
BUSHIPS NO 7

40 KTS

M.A.C. = .033 FE

SYMBOLS
VENTED



ANGLE OF ATTACK
± DEGREES

PITCHING MOM.
COEFF. ~ C_m

REPORT NO.

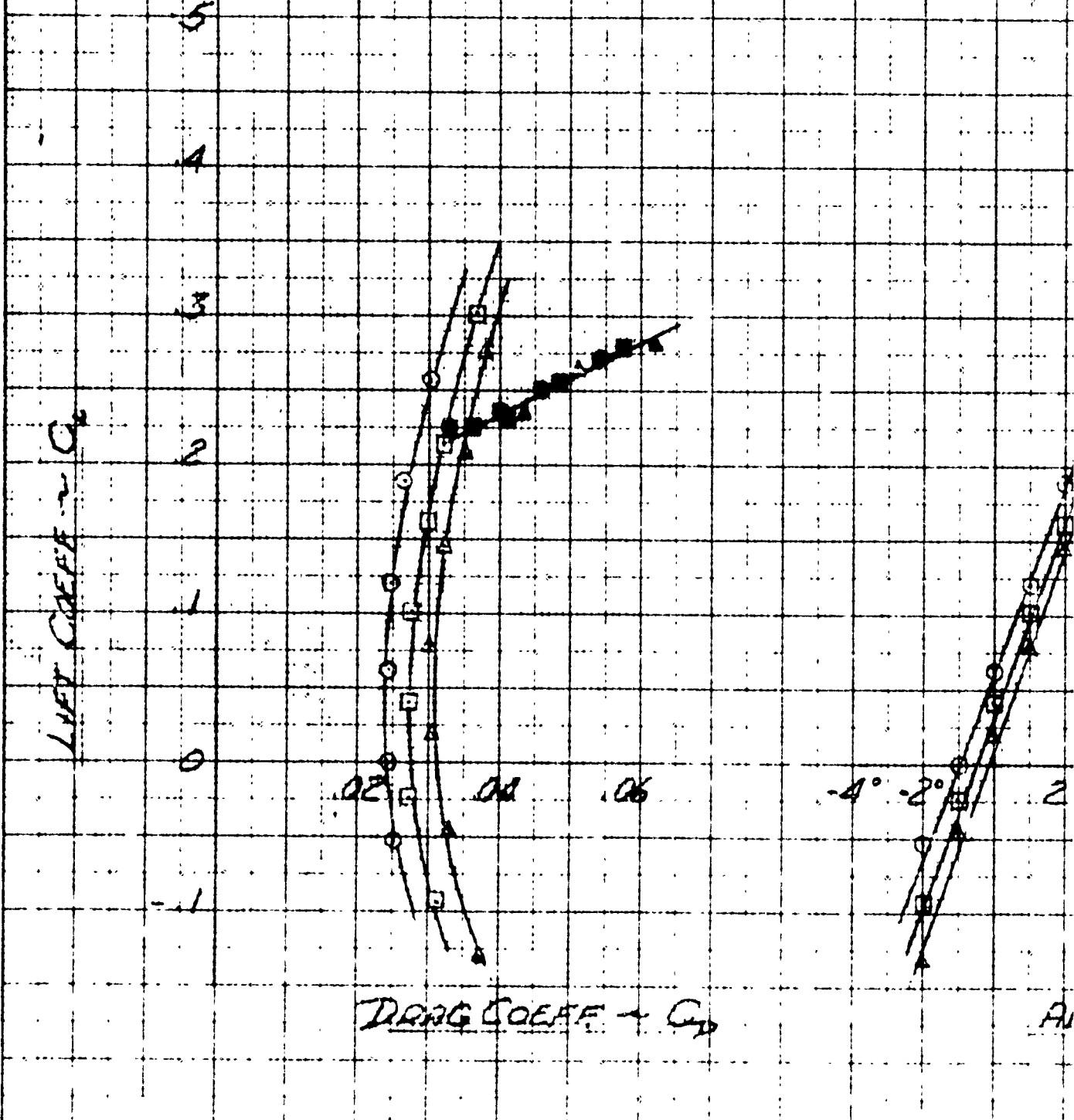
FROUDE NO.	CAV. NO.	SYMBOL	d/c
------------	----------	--------	-----

0.226	387	○	.75
7.1914	392	■	1.00
6.9031	377	▲	1.25

NOTE:

1. DARKENED SYMBOLS INDICATE VENT FLOW.

Lift Coefficient - C_L



Drag Coeff. + C_D

GRUMMAN AIRCRAFT ENGINE

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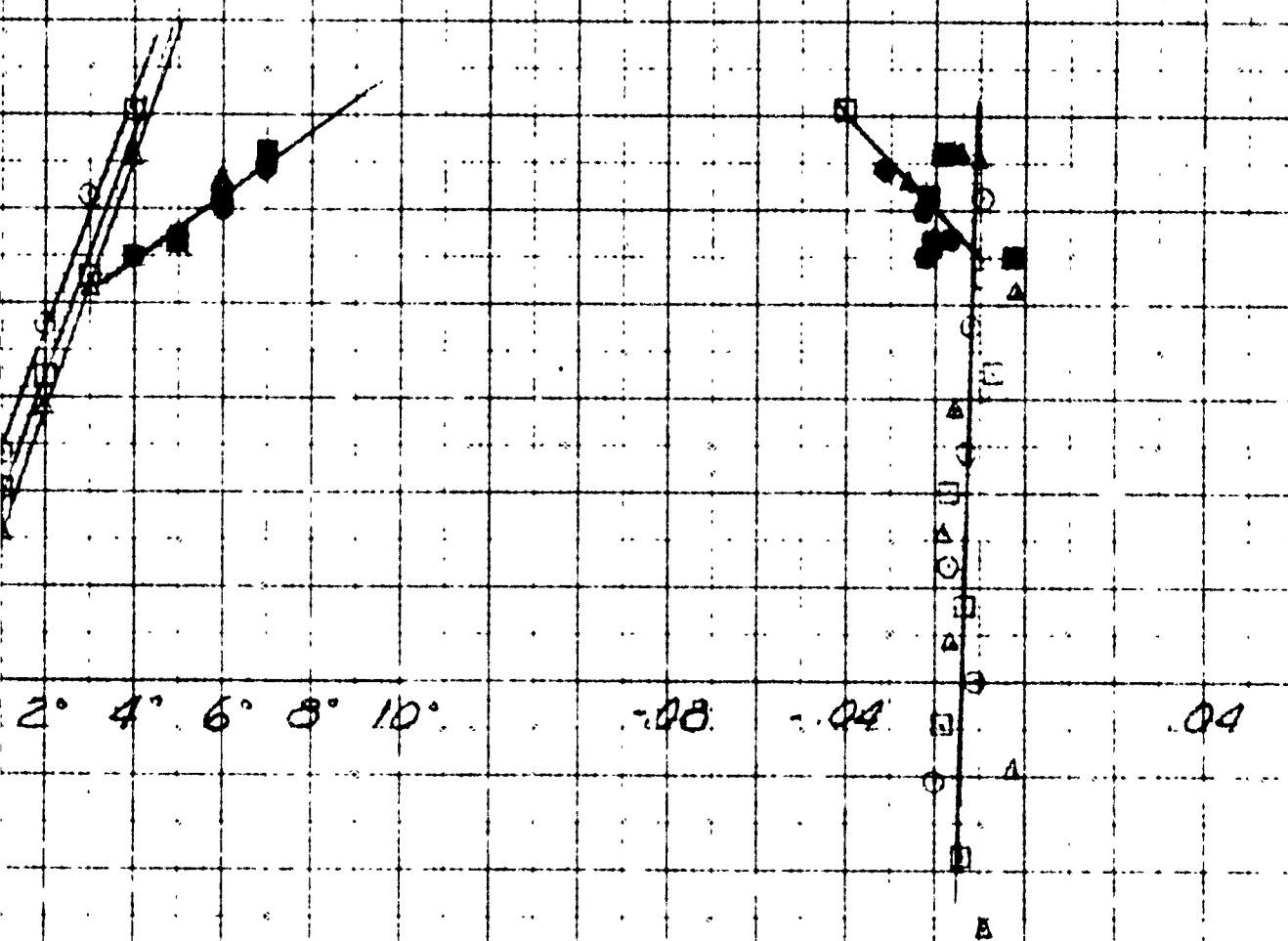
WHIRLING TANK TEST NO 20D

BUSHIPS NO. 7

45 KTS.

M.A.C. = 08.3 FT

VEOLS
NTED



ANGLE OF ATTACK
4° DEGREES

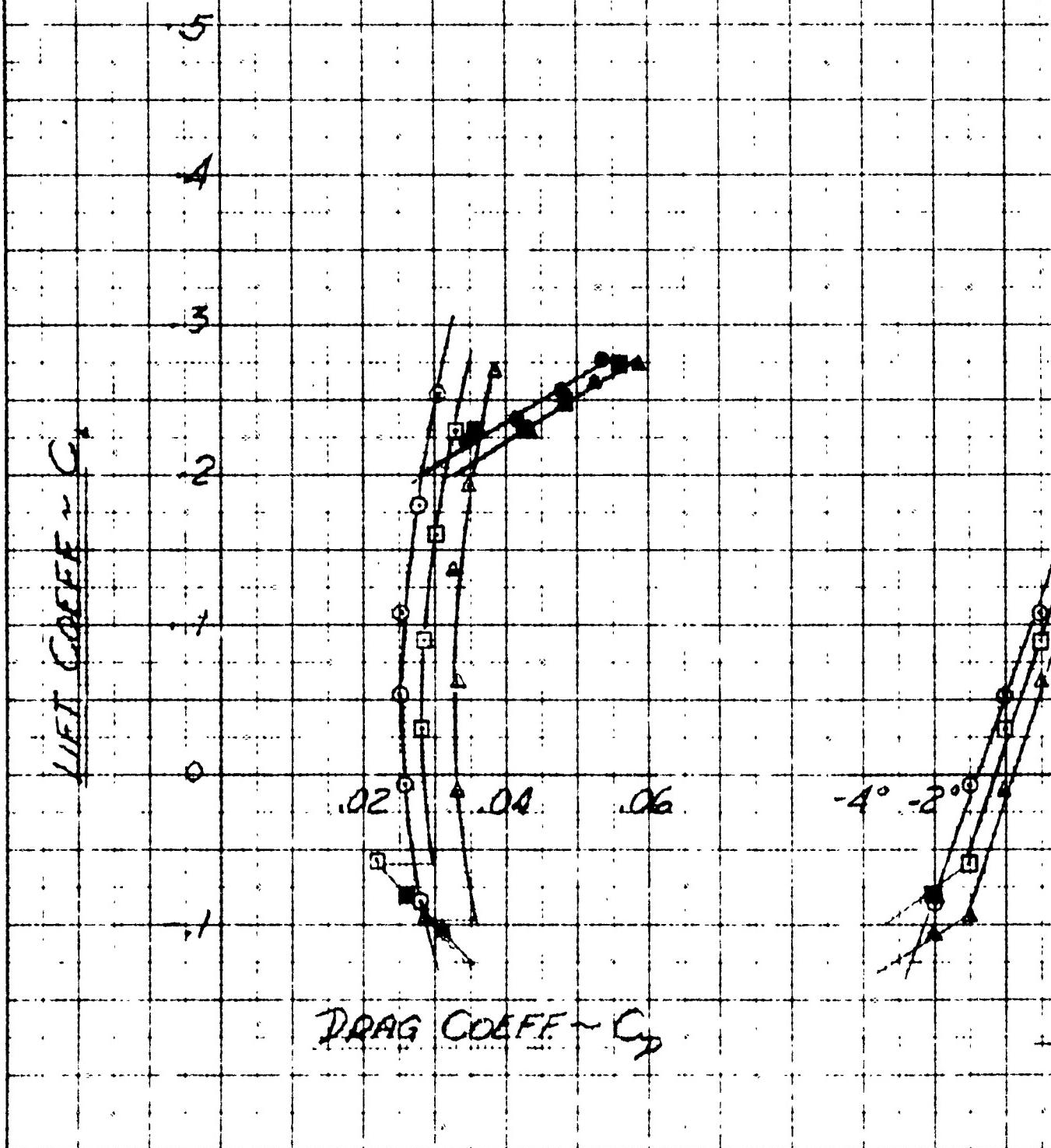
PITCHING MOM.
COEFF - C_p

REPORT NO

FREUDENBERG No. CAV. NO. 3 SYMBOL 9/C

3.2250	.317	0	15
7.1410	.224	0	1.00
64031	.229	A	1.25

NOTE:
1. DARKENED
INDICATE
FLO

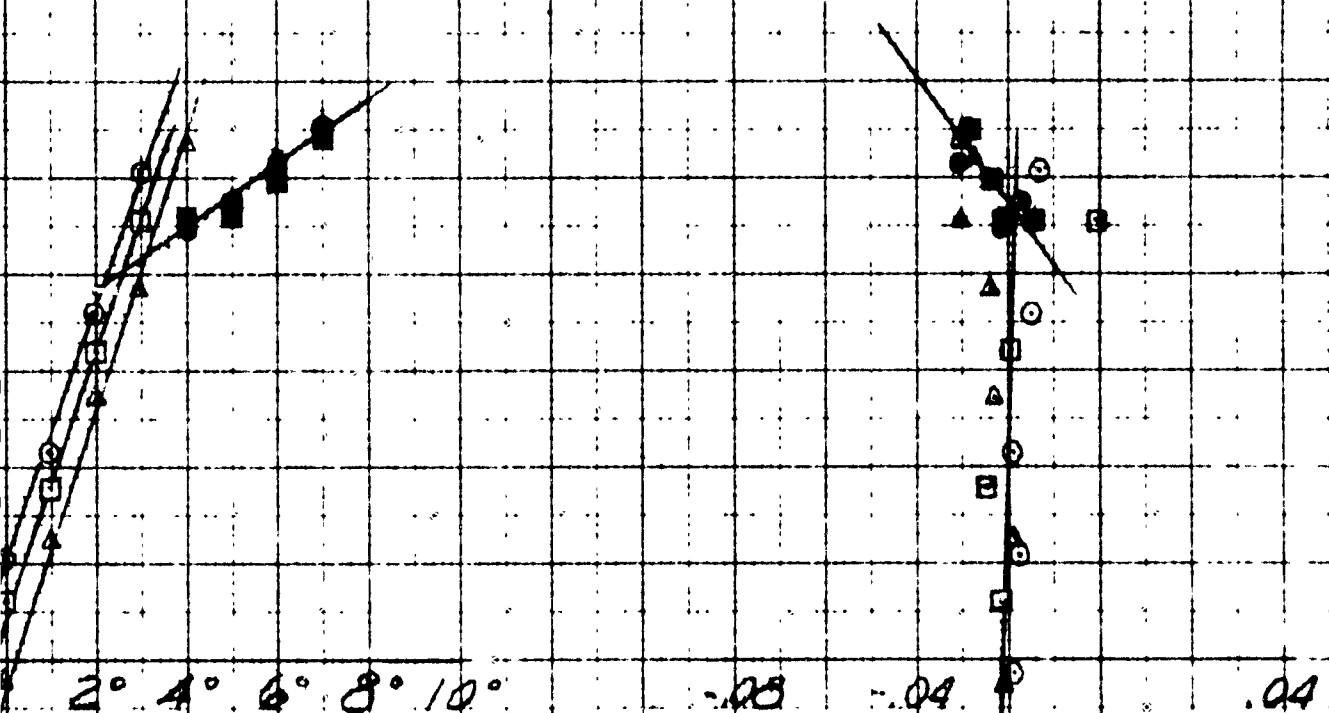


WHIRLING TANK TEST NO 20D
BUSHIPS NO. 7

50 KTS

M.A.C. = 283 FT

VED SYMBOLS
TE VENTED
LOW.



ANGLE of ATTACK
* ~ DEGREES

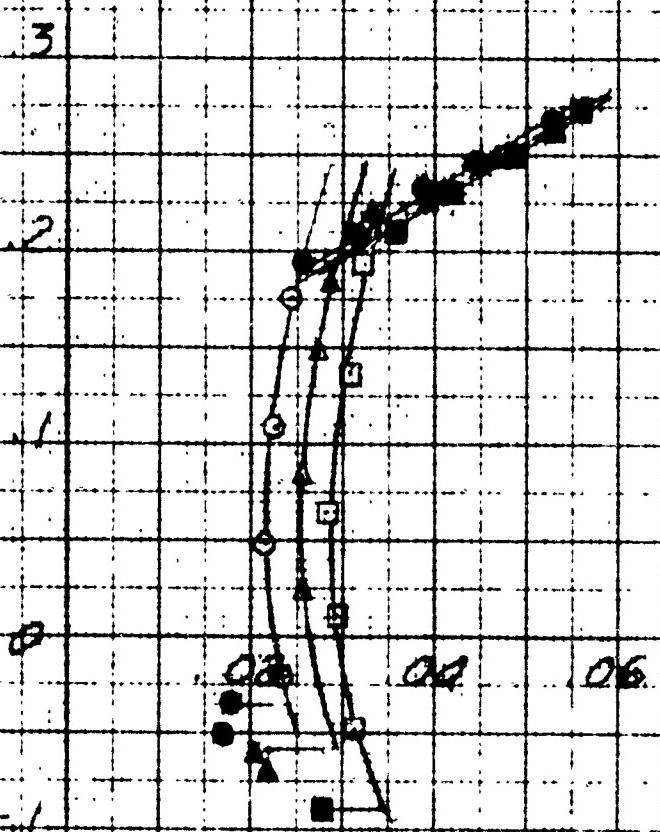
PITCHING MOM.
COEFF ~ C_M

FROUDE NO.	CIV. NO.	SYMBOL	ϕ/c
8.2262	230	o	.75
7.1414	234	o	1.00
6.4031	245	o	1.25

NOTE:

1. DARK
INDIC

JET COEFF - C_D



DRAG COEFF - C_D

-4° -2° 0°

2° 4°

6° 8°

10° 12°

14° 16°

18° 20°

24° 26°

30° 32°

36° 38°

42° 44°

48° 50°

54° 56°

60° 62°

66° 68°

72° 74°

78° 80°

84° 86°

90° 92°

96° 98°

102° 104°

108° 110°

114° 116°

120° 122°

126° 128°

132° 134°

136° 138°

142° 144°

148° 150°

154° 156°

160° 162°

166° 168°

172° 174°

178° 180°

184° 186°

190° 192°

196° 198°

202° 204°

208° 210°

214° 216°

220° 222°

226° 228°

232° 234°

238° 240°

244° 246°

250° 252°

256° 258°

262° 264°

268° 270°

274° 276°

280° 282°

286° 288°

292° 294°

298° 300°

304° 306°

310° 312°

316° 318°

322° 324°

328° 330°

334° 336°

340° 342°

346° 348°

352° 354°

358° 360°

364° 366°

370° 372°

376° 378°

382° 384°

388° 390°

394° 396°

400° 402°

406° 408°

412° 414°

418° 420°

424° 426°

430° 432°

436° 438°

442° 444°

448° 450°

454° 456°

460° 462°

466° 468°

472° 474°

478° 480°

484° 486°

490° 492°

496° 498°

502° 504°

508° 510°

514° 516°

520° 522°

526° 528°

532° 534°

538° 540°

544° 546°

550° 552°

556° 558°

562° 564°

568° 570°

574° 576°

580° 582°

586° 588°

592° 594°

598° 600°

604° 606°

610° 612°

616° 618°

622° 624°

628° 630°

634° 636°

640° 642°

646° 648°

652° 654°

658° 660°

664° 666°

670° 672°

676° 678°

682° 684°

688° 690°

694° 696°

700° 702°

706° 708°

712° 714°

718° 720°

724° 726°

730° 732°

736° 738°

742° 744°

748° 750°

754° 756°

760° 762°

766° 768°

772° 774°

778° 780°

784° 786°

790° 792°

796° 798°

802° 804°

808° 810°

814° 816°

820° 822°

826° 828°

832° 834°

838° 840°

844° 846°

850° 852°

856° 858°

862° 864°

868° 870°

874° 876°

880° 882°

886° 888°

892° 894°

898° 900°

904° 906°

910° 912°

916° 918°

922° 924°

928° 930°

934° 936°

940° 942°

946° 948°

952° 954°

958° 960°

964° 966°

970° 972°

976° 978°

982° 984°

988° 990°

996° 998°

1002° 1004°

1008° 1010°

1016° 1018°

1022° 1024°

1028° 1030°

1034° 1036°

1040° 1042°

1046° 1048°

1052° 1054°

1058° 1060°

1064° 1066°

1070° 1072°

1076° 1078°

1082° 1084°

1088° 1090°

1096° 1098°

1102° 1104°

1108° 1110°

1116° 1118°

1122° 1124°

1128° 1130°

1134° 1136°

1140° 1142°

1146° 1148°

1152° 1154°

1158° 1160°

1164° 1166°

1170° 1172°

1176° 1178°

1182° 1184°

1188° 1190°

1196° 1198°

1202° 1204°

1208° 1210°

1216° 1218°

1222° 1224°

1228° 1230°

1234° 1236°

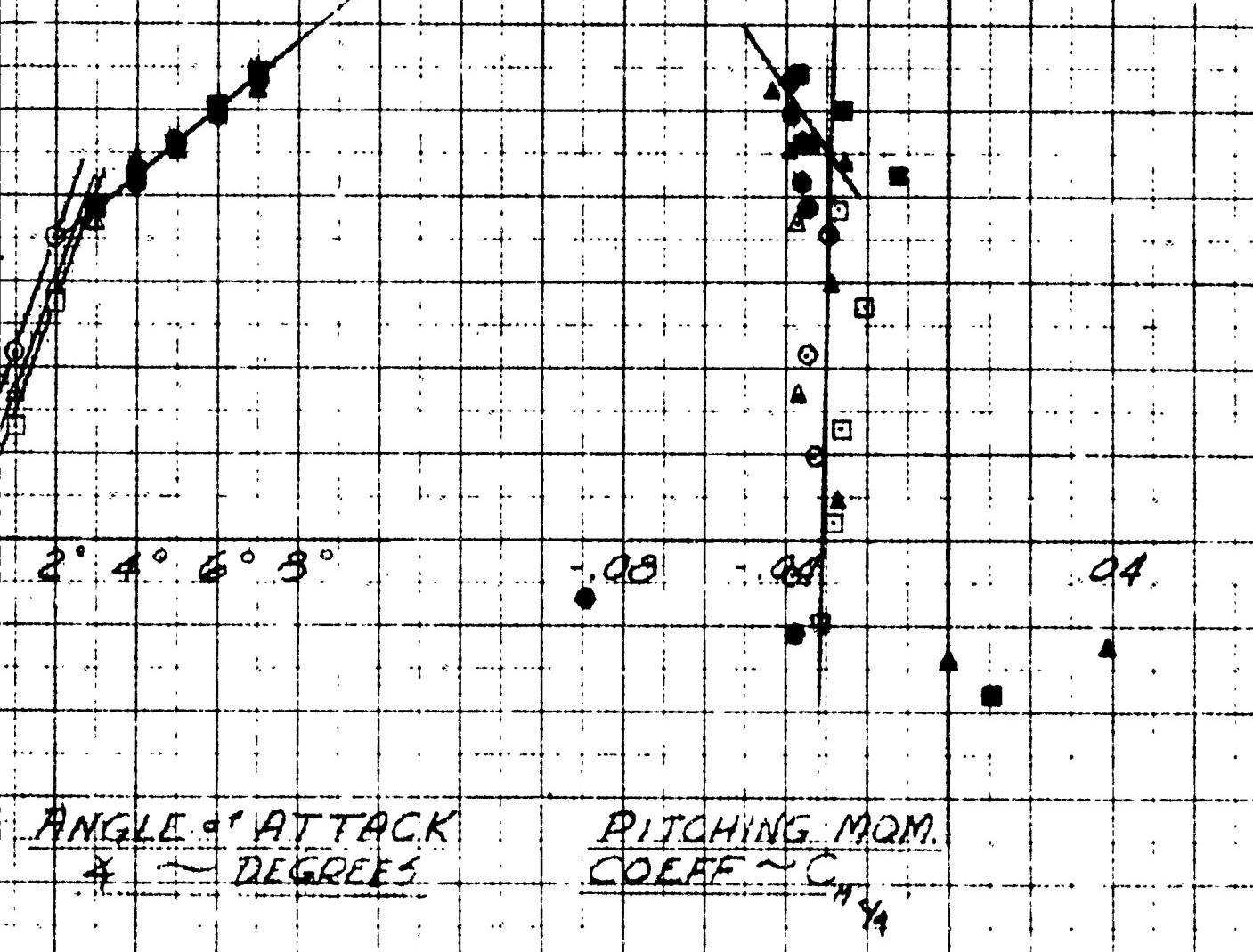
1240° 1242°

1246° 1248°

1252° 1254°

WHIRLING TANK TEST NO 20D
 BUSHIPS NO 7
 60 KTS
 MAC. = 003 FT

MARKED SYMBOLS
 INDICATE VENTED
 FLOW.

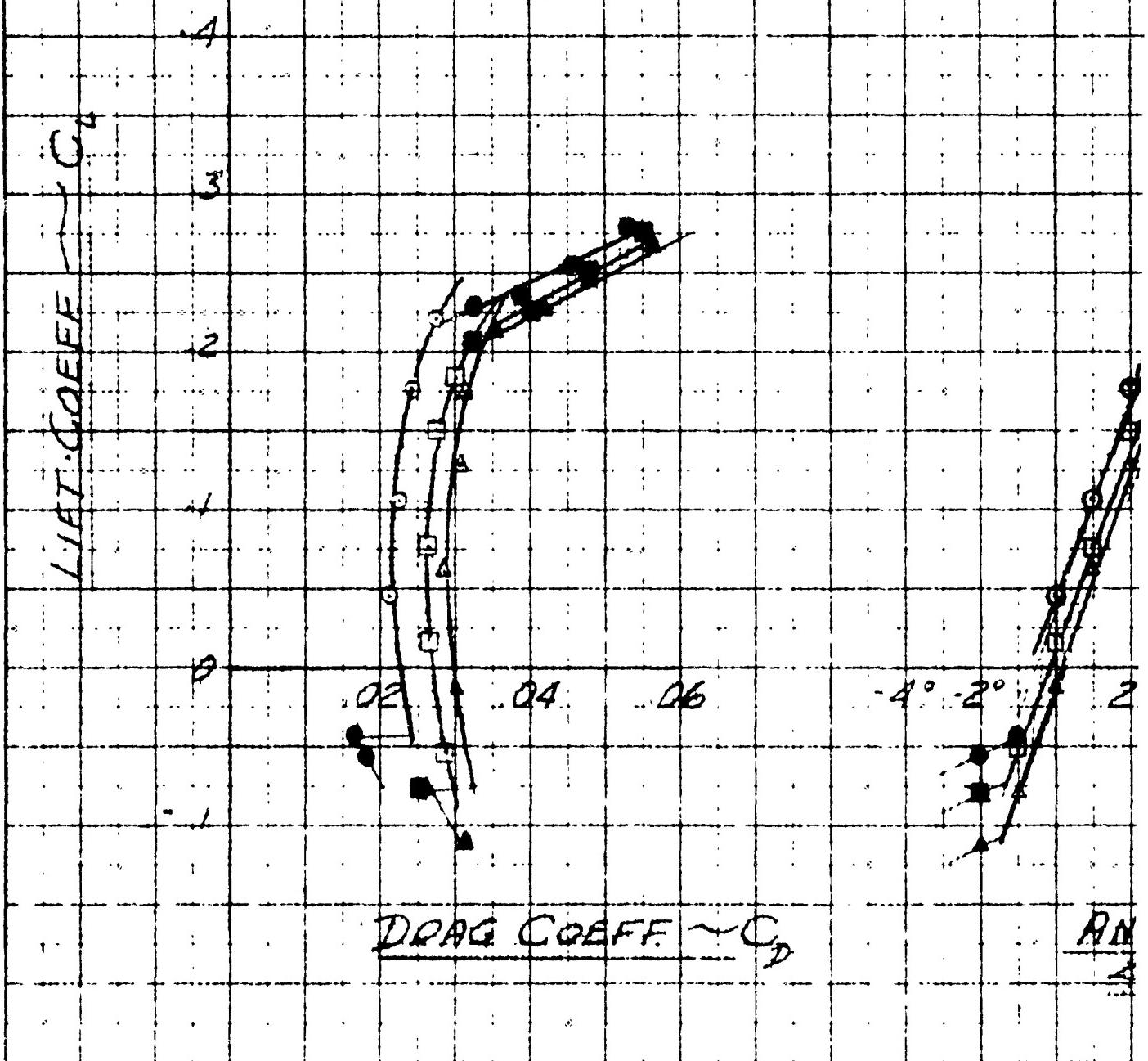


ANGLE OF ATTACK
 # DEGREES

PITCHING MOM.
 COEFF ~ C_p

PRODUCER NO	CAV. NO	SYMBOL	%
8.2260	.178	○	75
7.1414	.185	□	100
6.9031	.192	▲	125

NOTE:
1. DARKER
INDICATES
HIGHER



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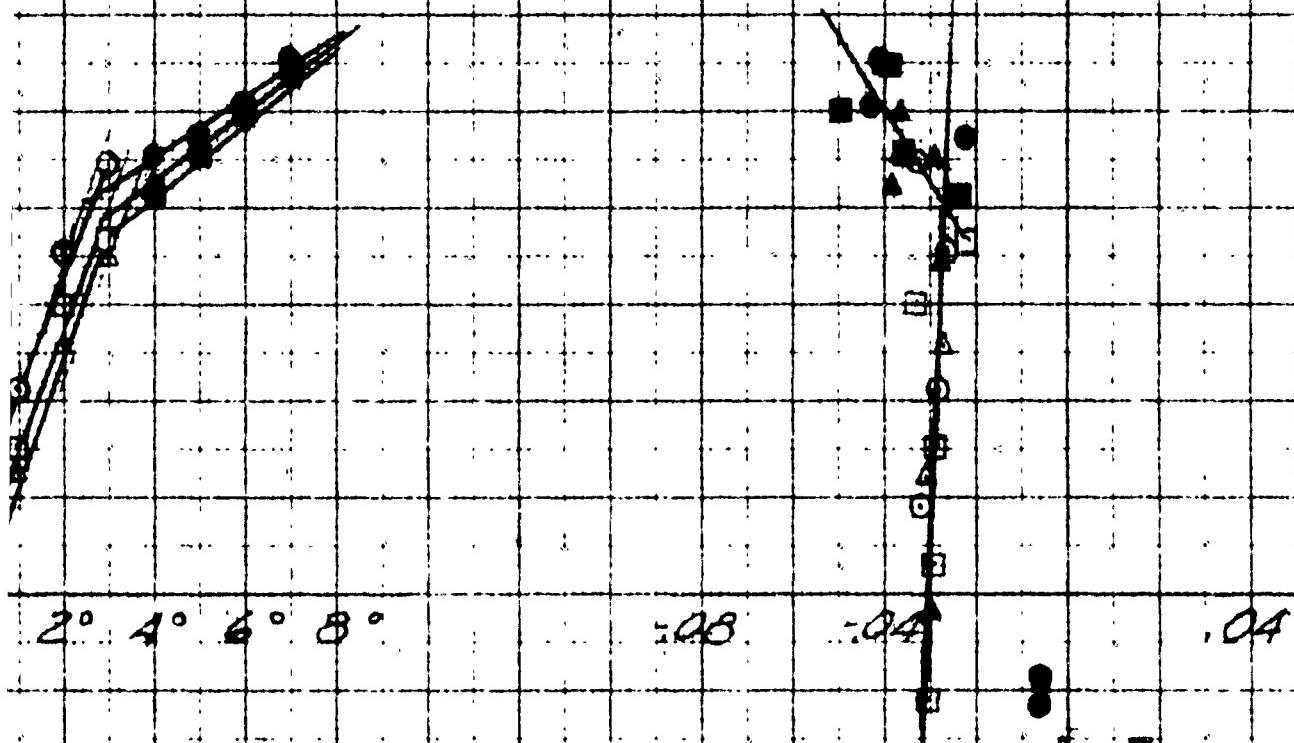
WHIRLING TANK TEST NO 20 D

BUSHIPS NO 7

70 KTS

M.A.C. = .083 FT.

LENEED SYMBOLS
ICATE VENTED
FLOW

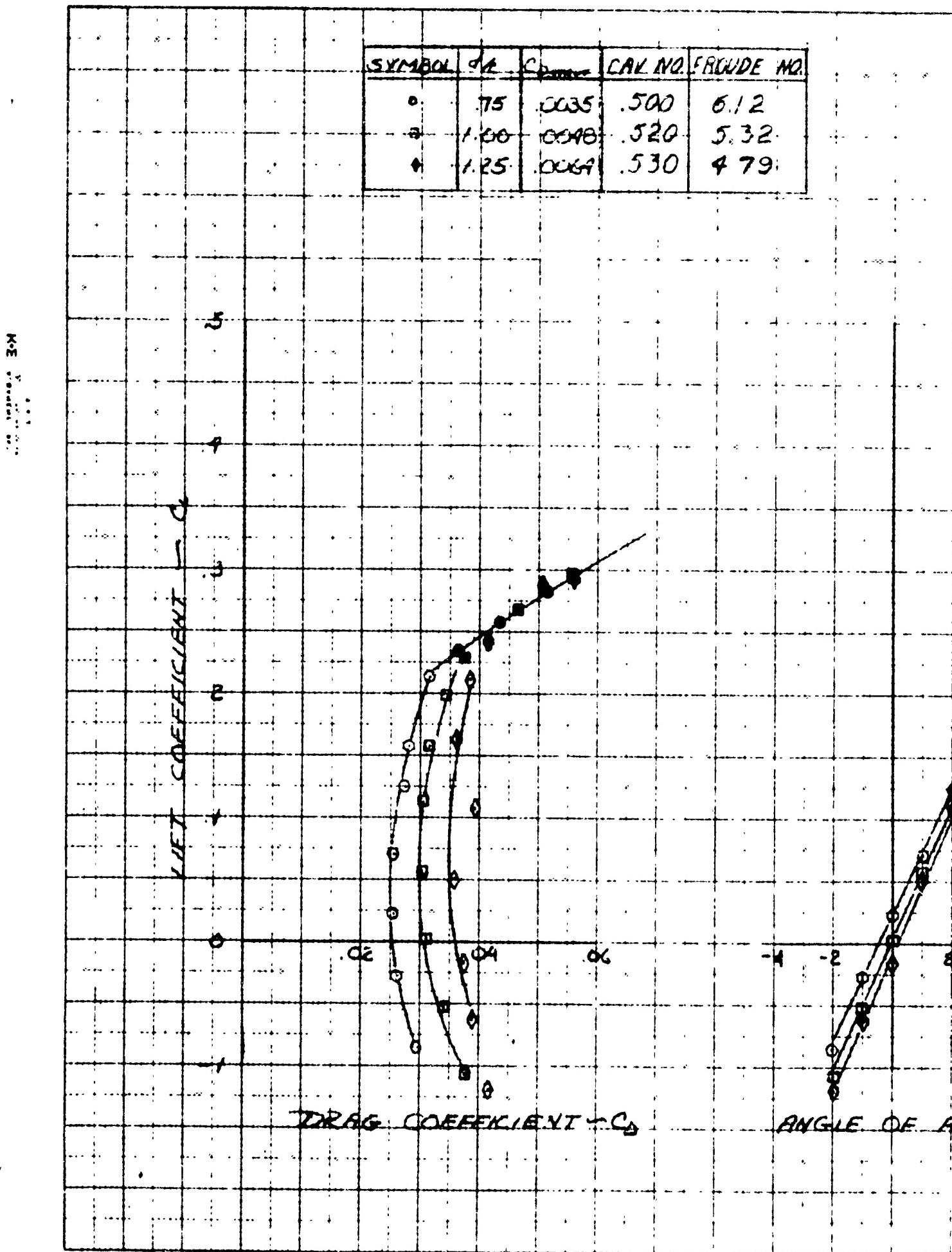


ANGLE OF ATTACK
DEGREES

PITCHING MOM.
COEFF ~

M_{ch}

REPORT NO



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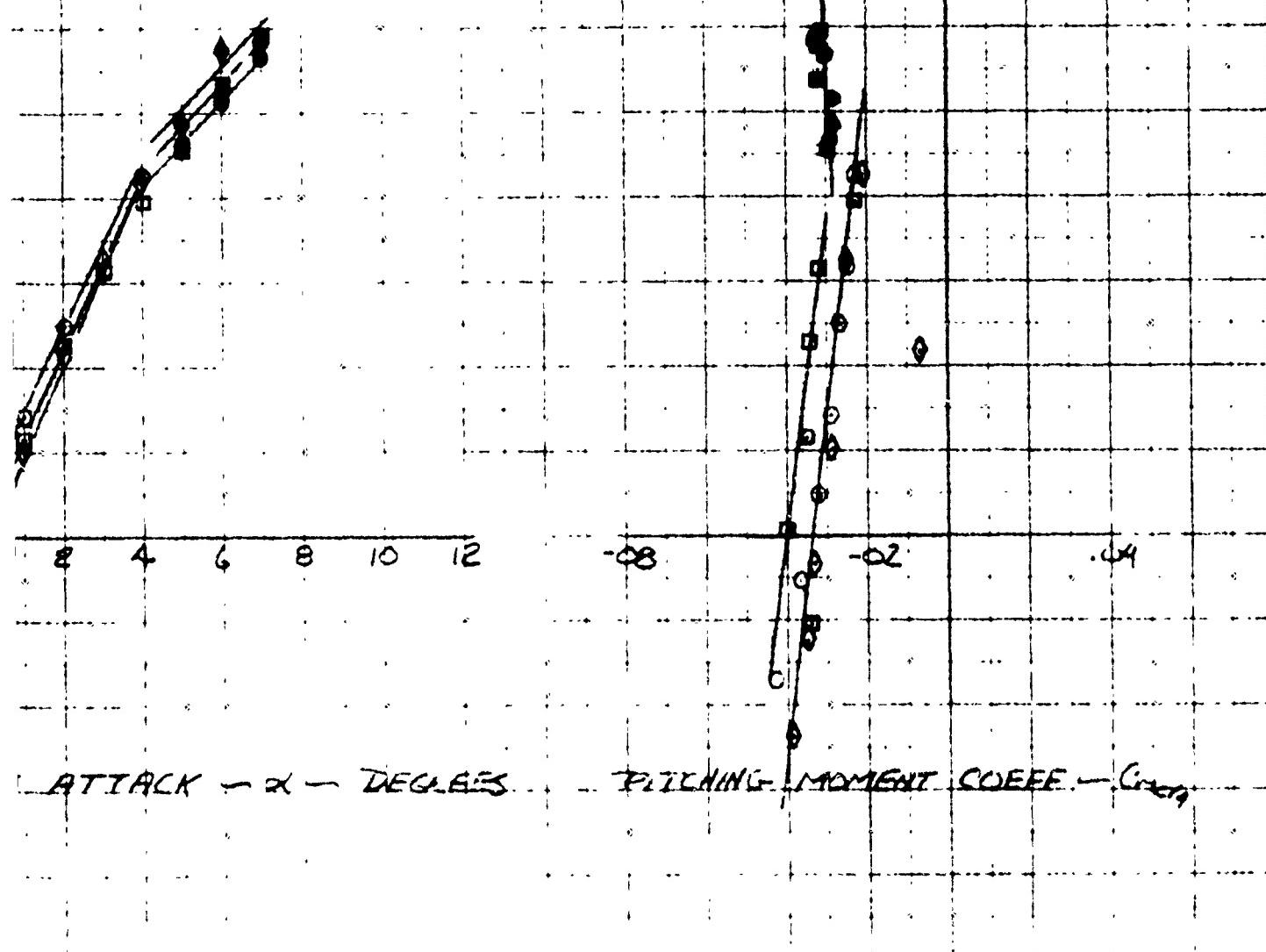
WHIRLING TANK TEST N2.20.C.

NO.6: 84954

MODEL NO. 3

40 KTS

MALE = 152 FT.



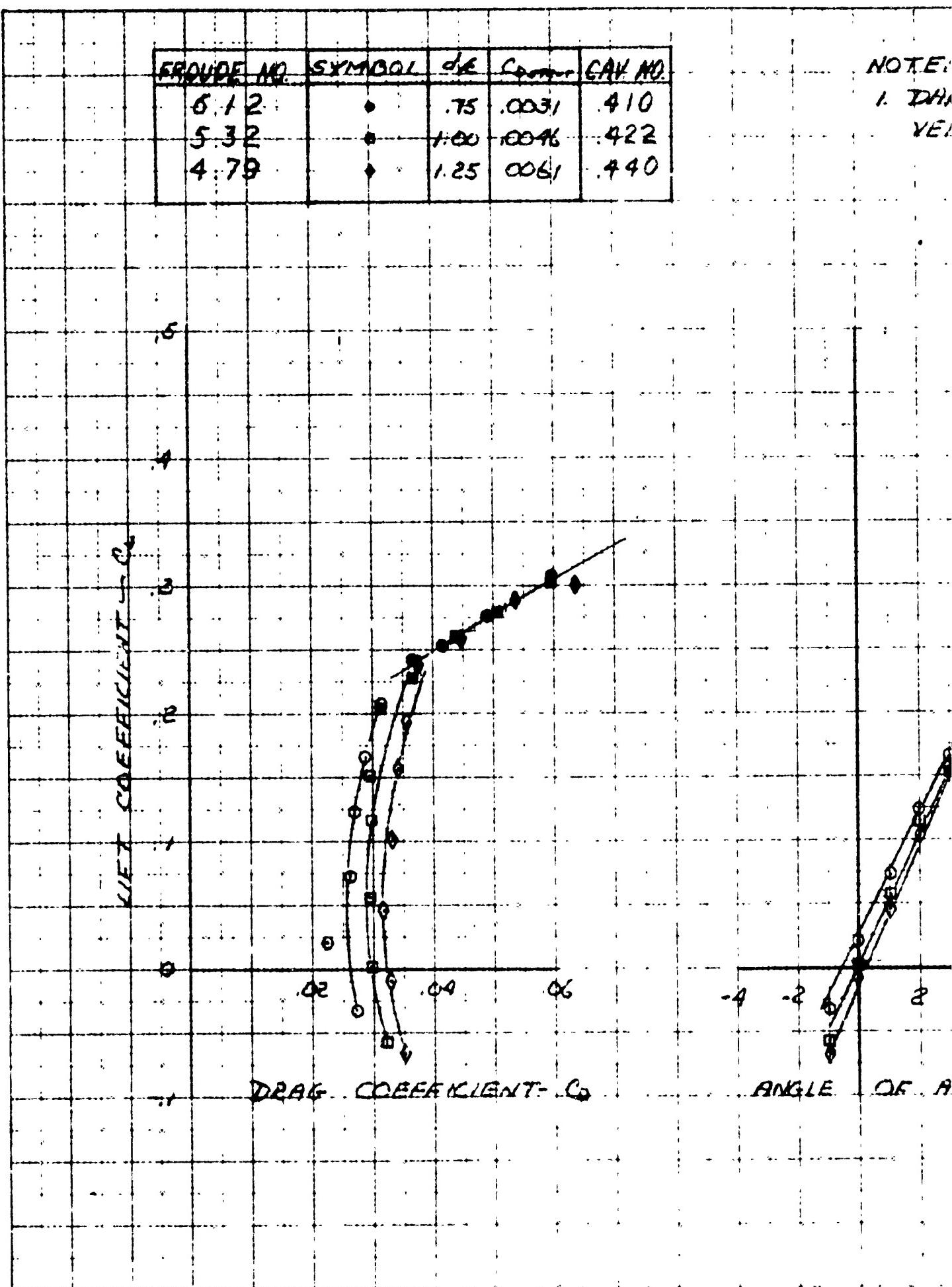
NOTE:

1. DIA.

VEL.

FRONDE NO.	SYMBOL	DE	CENTER	GAV NO.
6.12	•	.75	.0031	410
5.32	•	1.00	.0046	422
4.78	♦	1.25	.0061	440

K-E
Aero. Eng.



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WHIRLING TANK TEST NO. 506

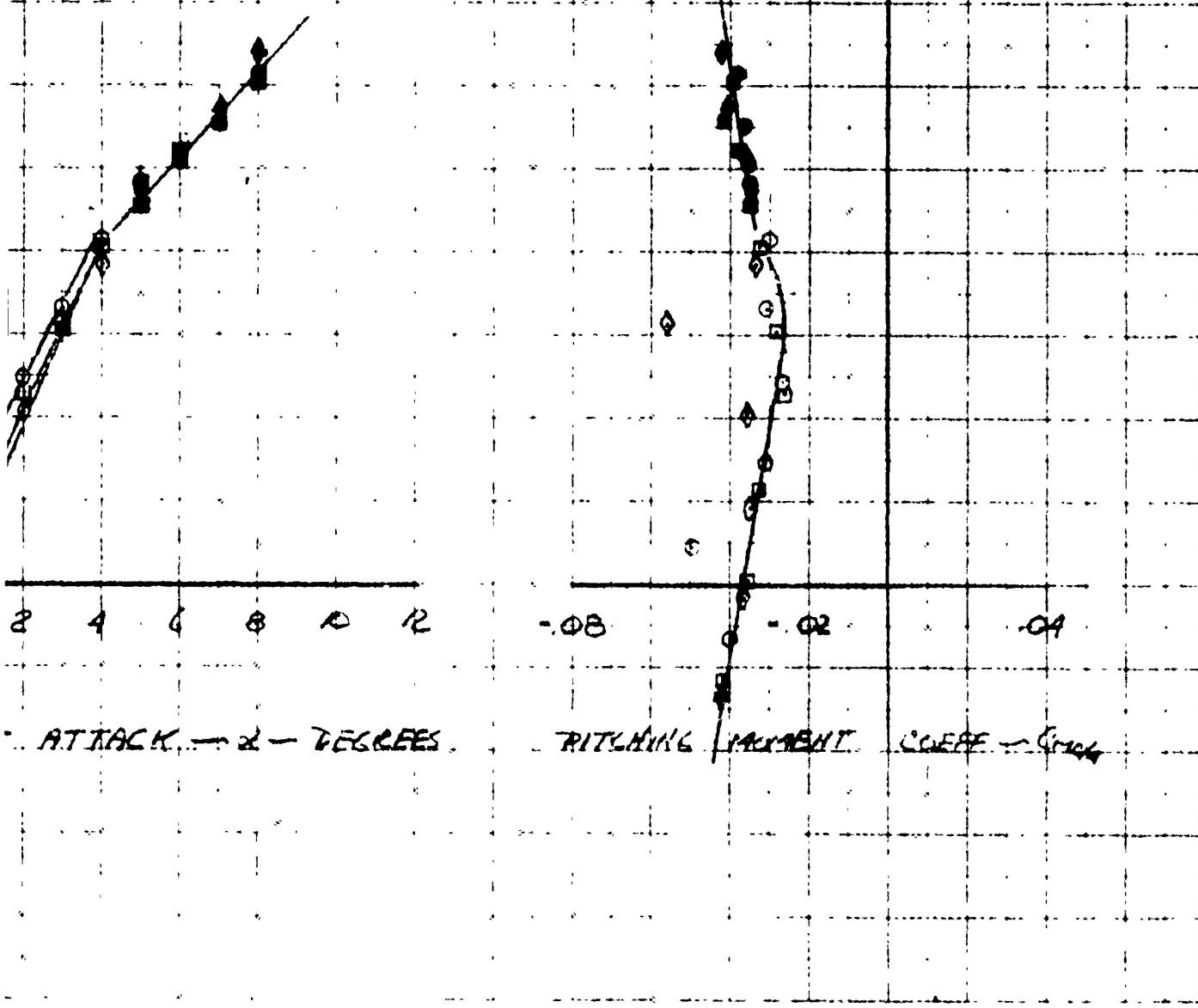
NO. 53 89454

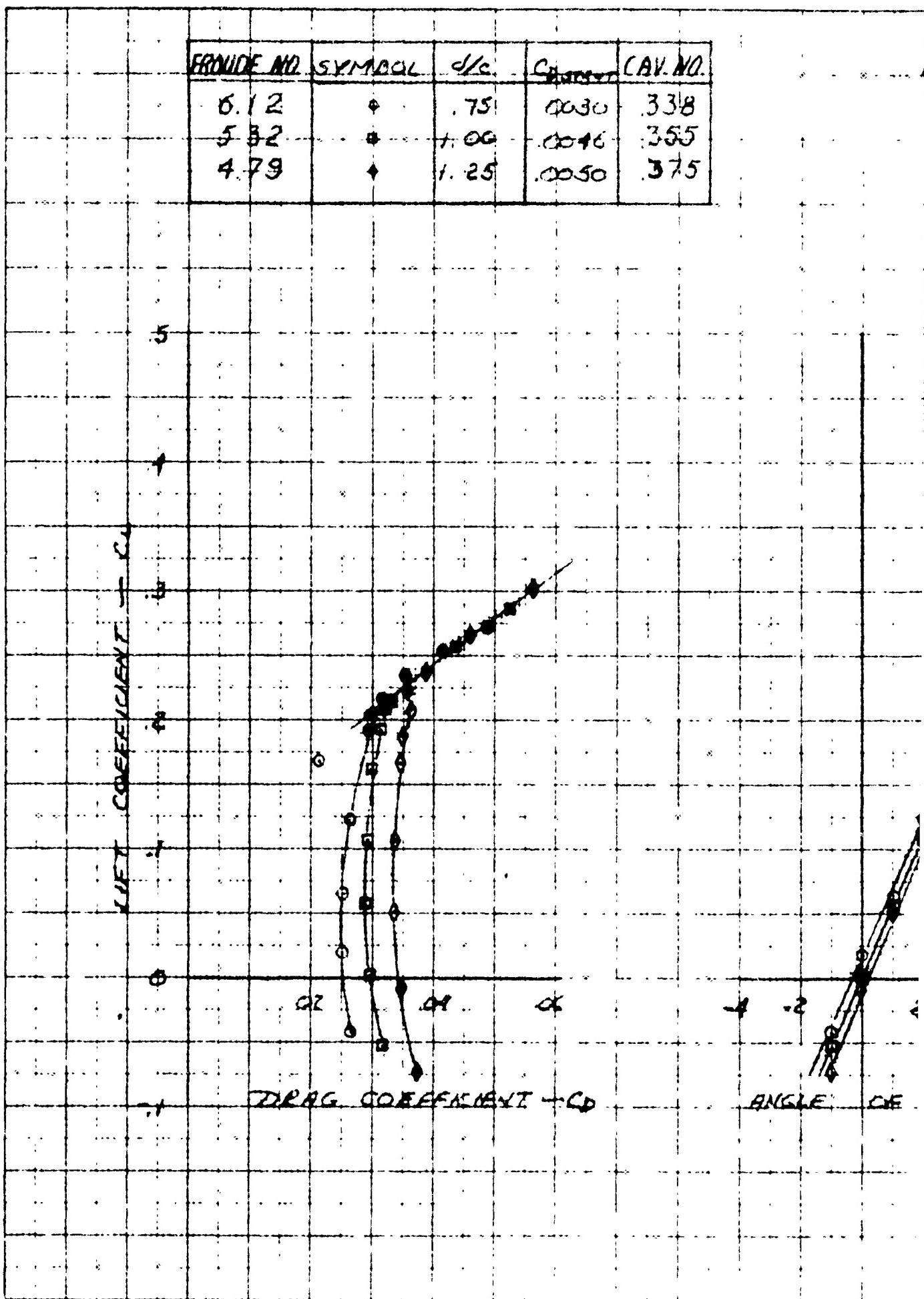
MODEL NO. 5

45 KTS

1000 = 1.52 ft.

TEI
DARKENED POINTS INDICATE
VENTED FLOW





PAGE IV.42

NOTE:

1. DARKENED SYMBOLS INDICATE
VENTED FLOW.

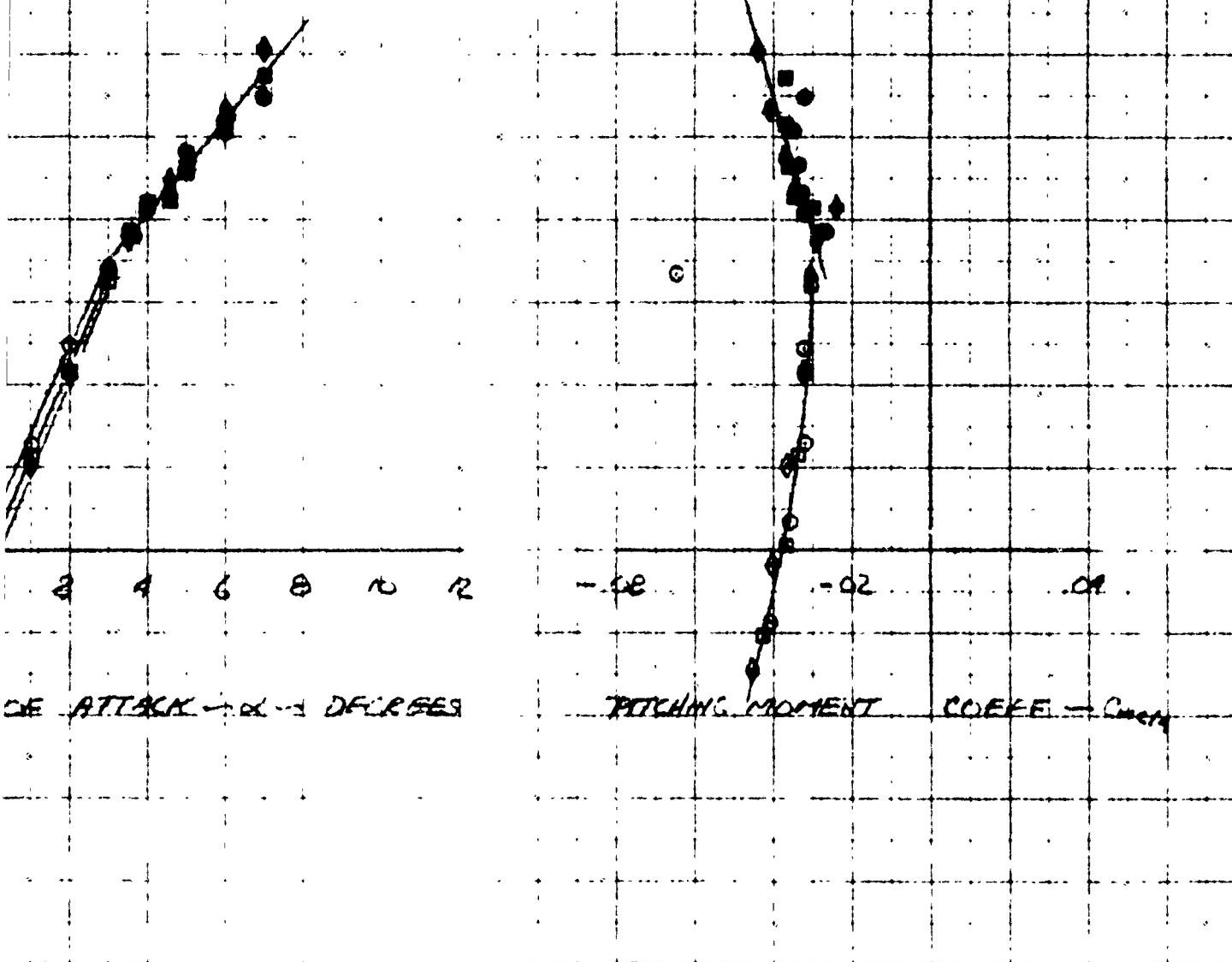
WHIRLING TANK TEST NO. 20C

NO. 1-3 39954

MODEL N-8

40 KTS

M.A. = .152 FT



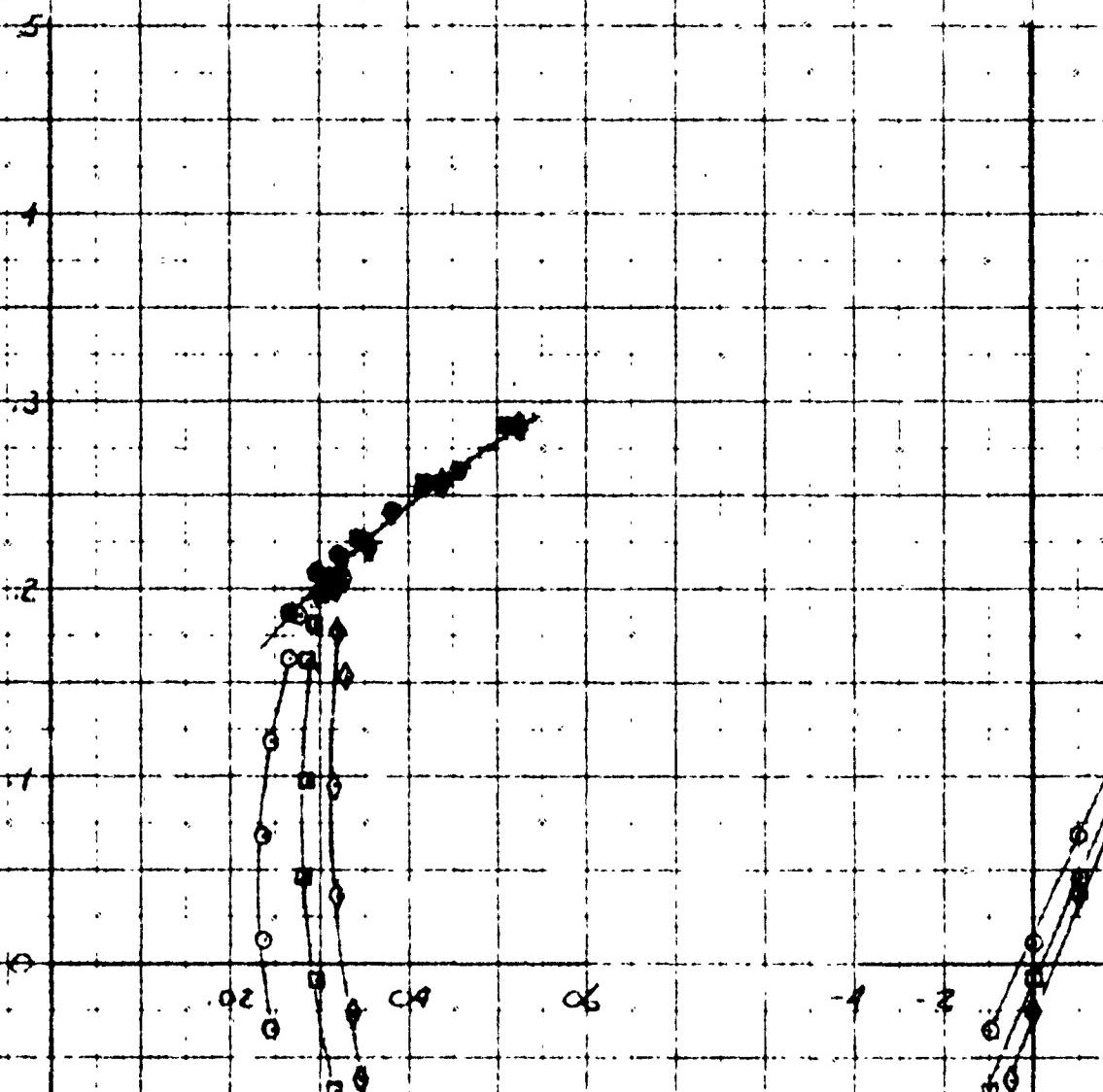
FAMIDE NO.	SYMBOL	$\frac{dA}{dx}$	Calcd	CAL NO.	NO.
6.12	♦	.75	.0030	250	1
5.32	•	1.00	.0045	268	
4.79	○	1.25	.0060	282	

KOE

JET COEFFICIENT - C_J

DRAg COEFFICIENT - C_D

ANGLE OF



PAGE IV.43

NOTE

1 DARKENED SYMBOLS INDICATE
VENTED FLOOR

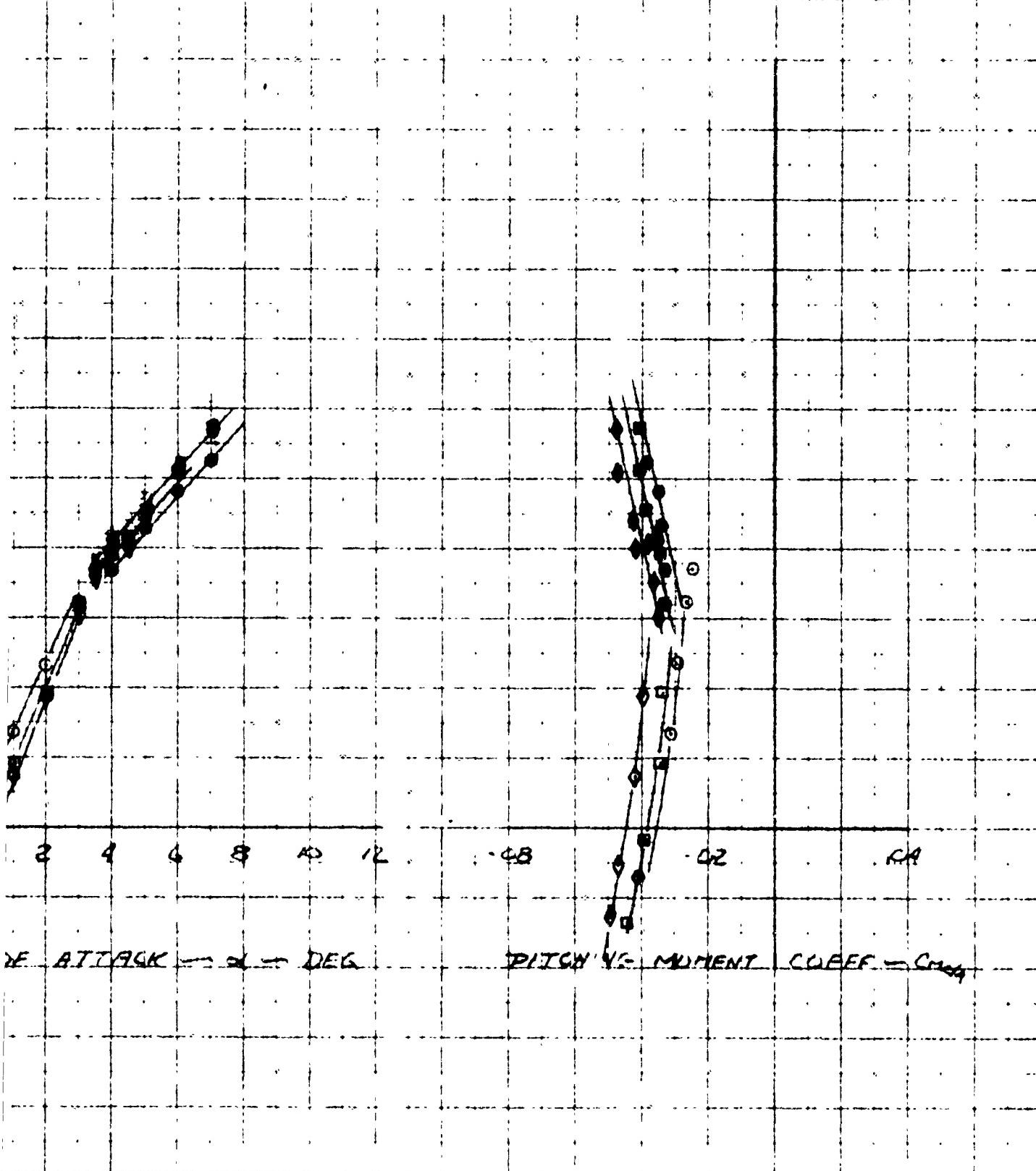
WHIRLING TANK TEST NO. 26A.C.

NO. 63 84954

MODEL NO. B

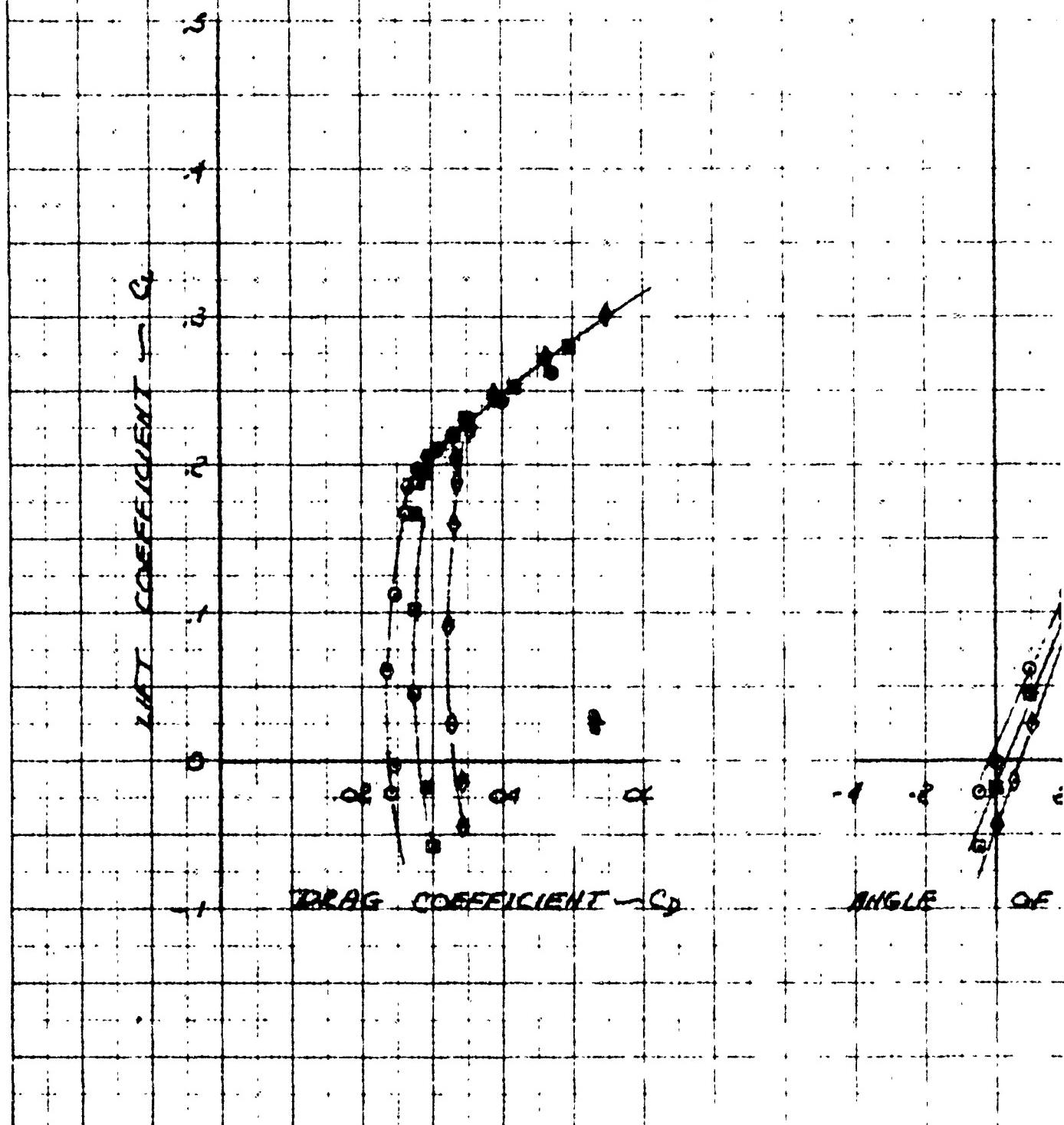
60 KTS

M.O.C. = 15 d.F.



SHROUD NO.	SYMBOL	d_k	Corr.	CAR NO.
5.12	*	.75	.0042	198
5.32	*	1.00	.0060	215
4.79	*	1.25	.0077	230

NOTE:
 1. DARI
 VENT



PAGE 14.44

WHIRLING TANK TEST NO. 20C.

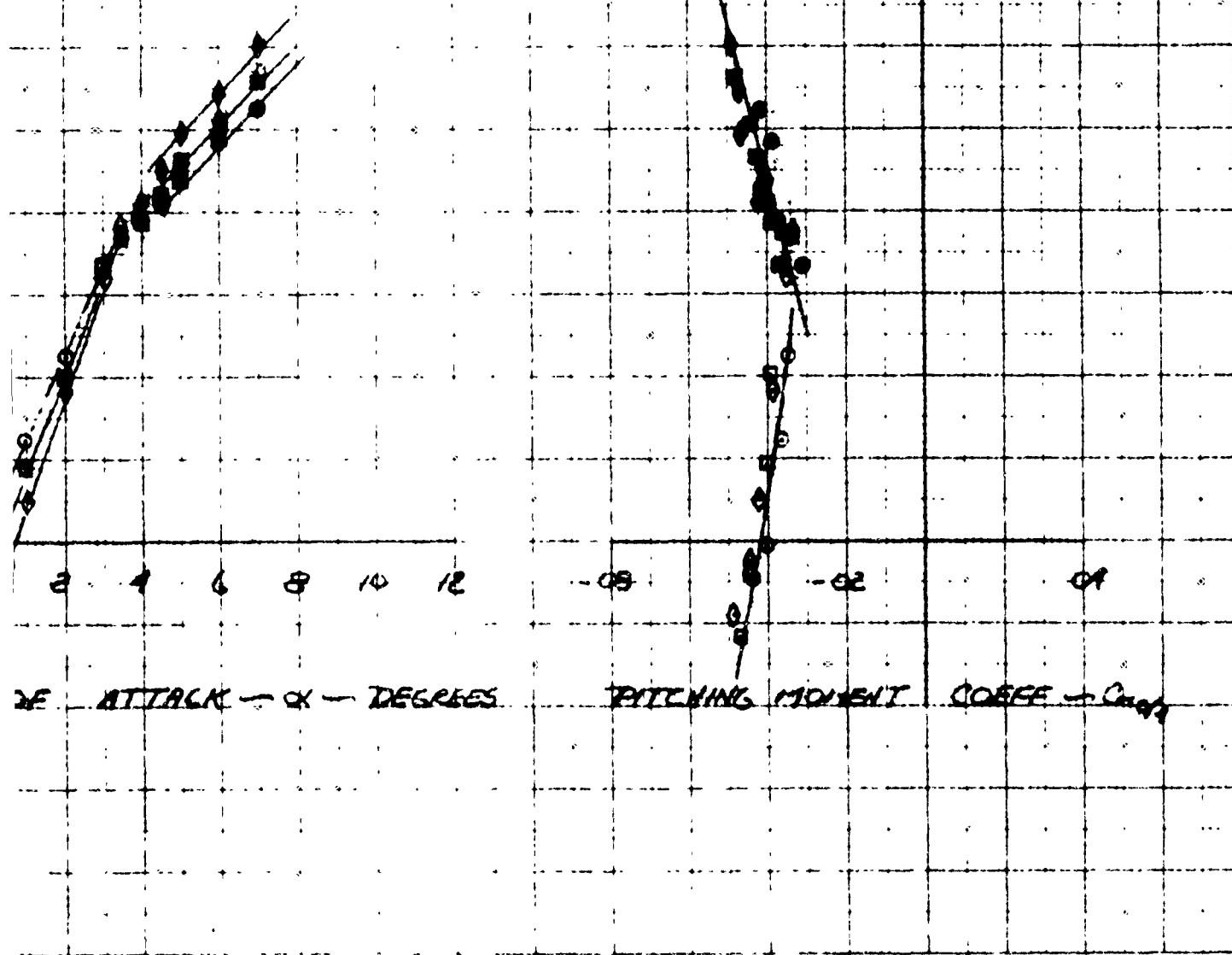
NO. 6s 84154

MODEL NO. 8

70 KTS

MHC = 15.2 FT.

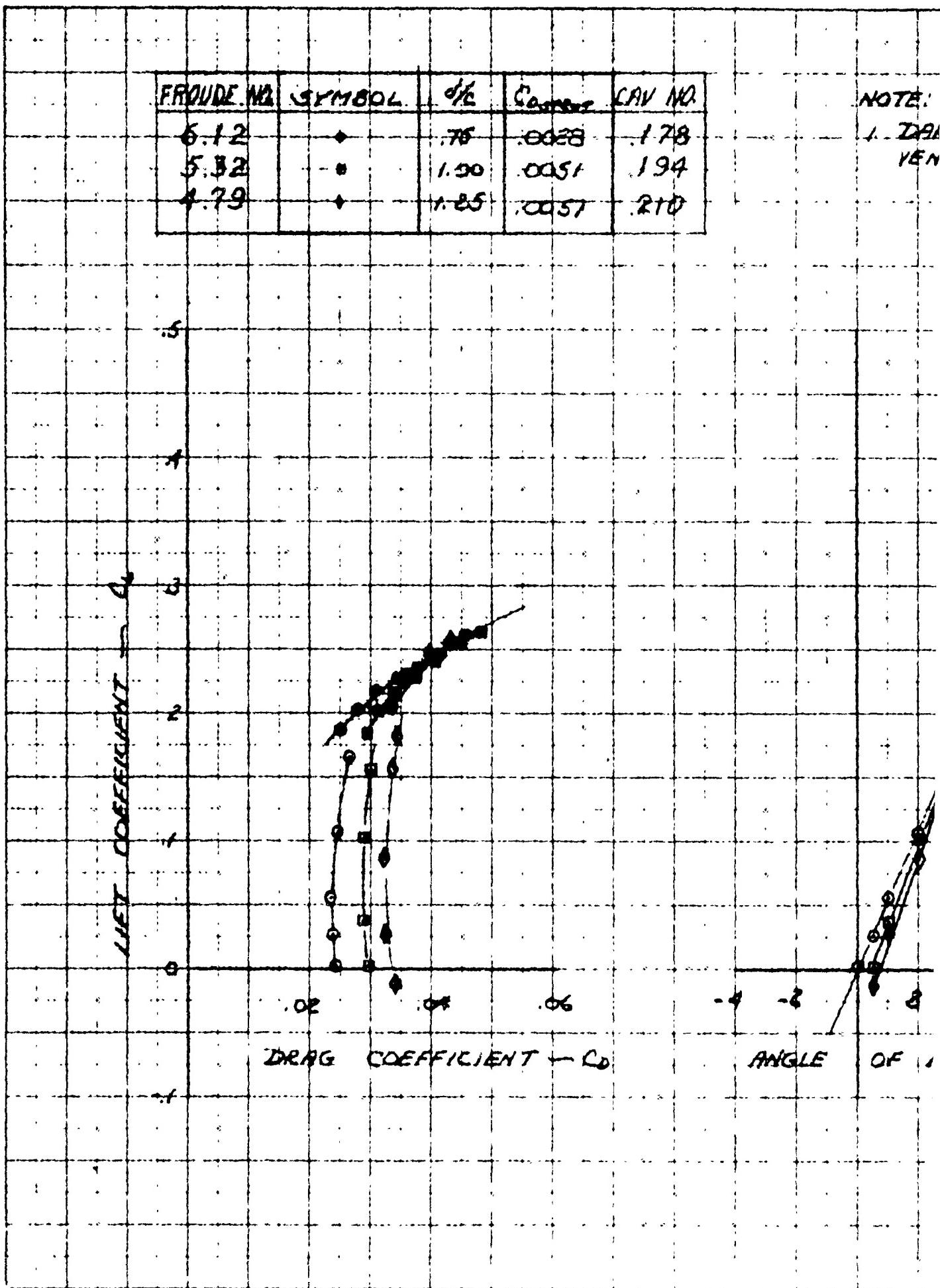
MARKED SYMBOLS INDICATE
REVERSE FLOW.



FROUDE NO	SYMBOL	d/c	Cav. pres.	CAV NO
6.12	◆	.78	.0038	178
5.32	●	1.00	.0051	194
4.79	◆	1.85	.0057	210

NOTE:
1. DRA
VEN

M.E.
1940



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WHIRLING TANK TEST NO 206

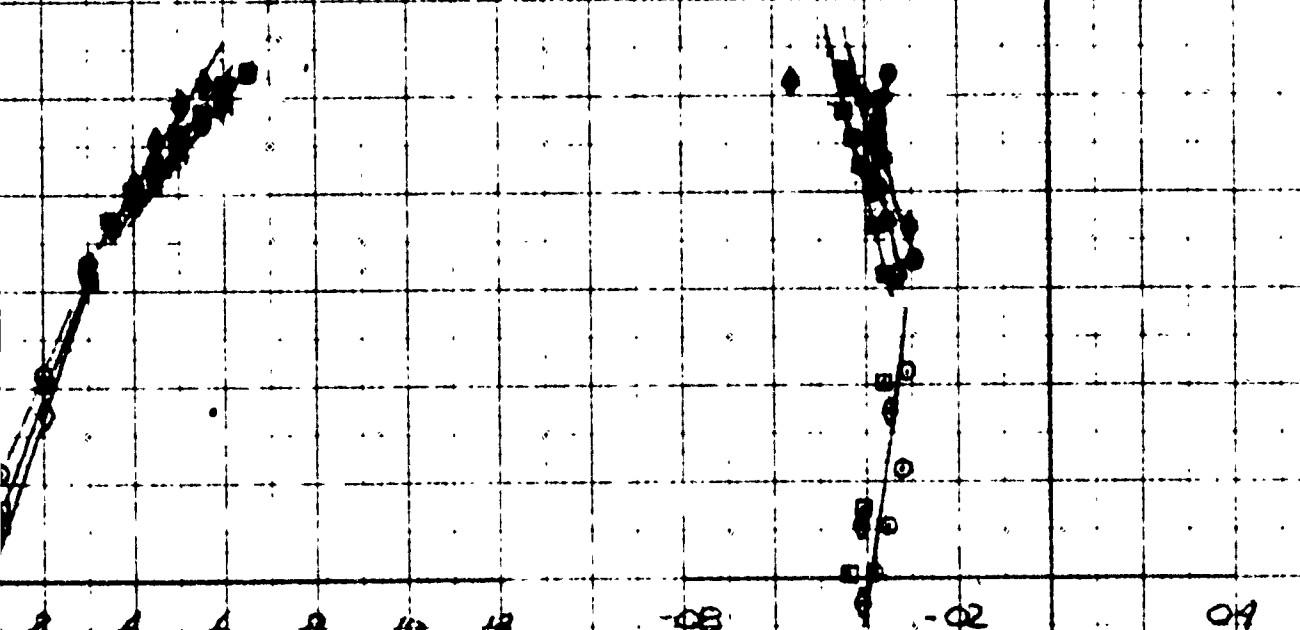
NOS. 89454

MODEL NOB

BOATS

12 B.C. 4.52 FT

TE
DARKENED SYMBOLS INDICATE
VENTED FLOW

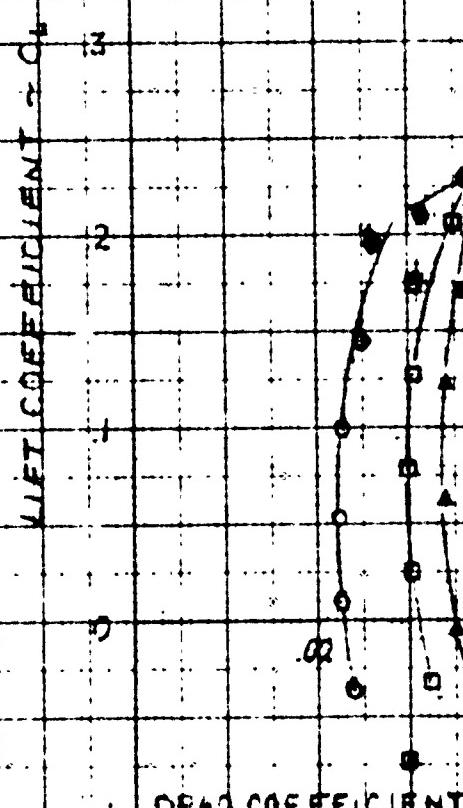


ANGLE OF ATTACK - α - DEGREES PITCHING MOMENT COEFF. - C_m

NOTE:

1. DARK
VE

SYMBOL	d/c	CONSTANT	CAR. NO.	AROUDÉ NO.
○	.75	.0035	.500	6.12
□	1.00	.0049	.519	5.32
▲	1.25	.0065	.532	4.79



GRUMMAN AIRCRAFT ENGINEER

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WHIRLING TANK TEST NO. 26E

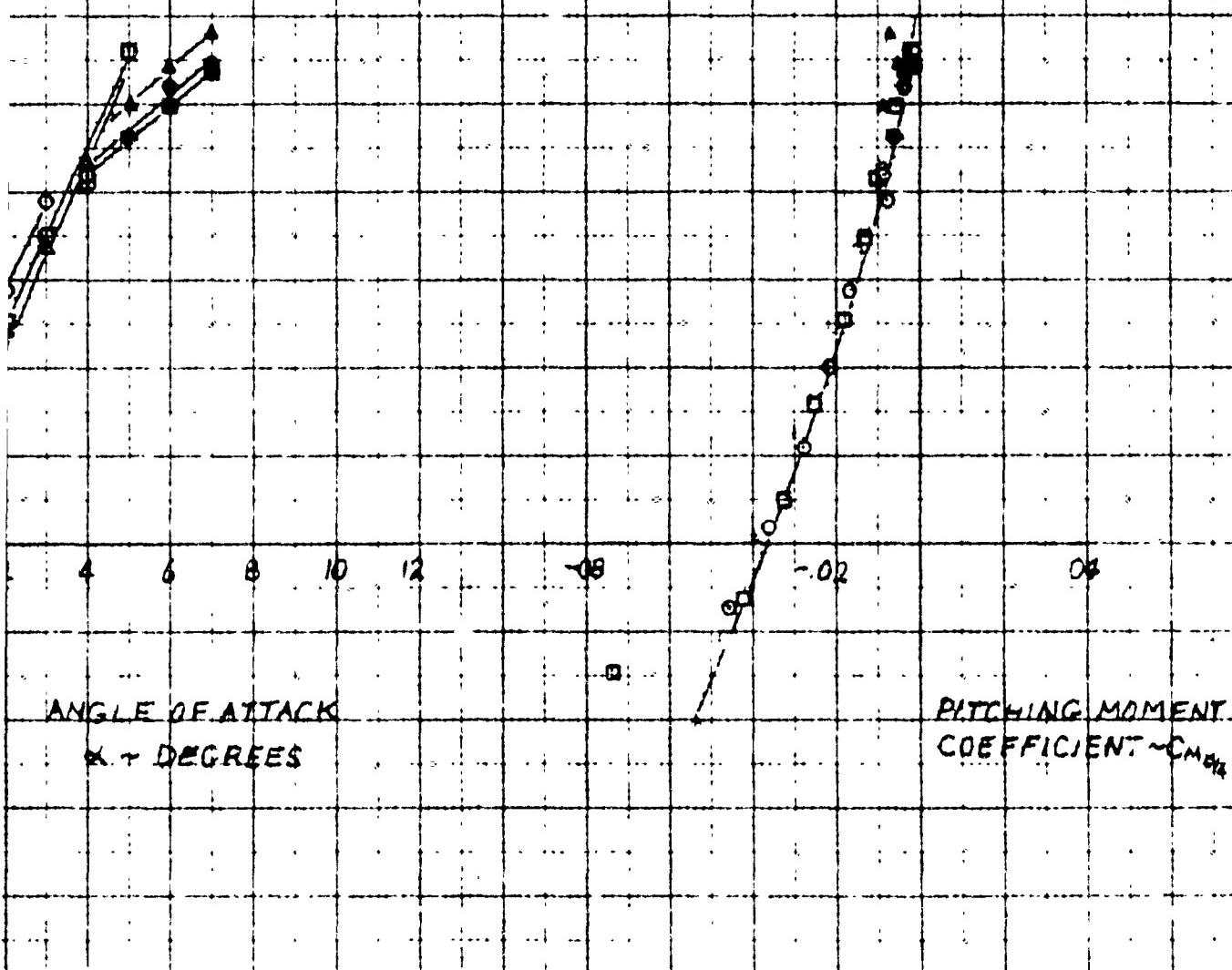
NO. 65-84454

MODEL NO. 9

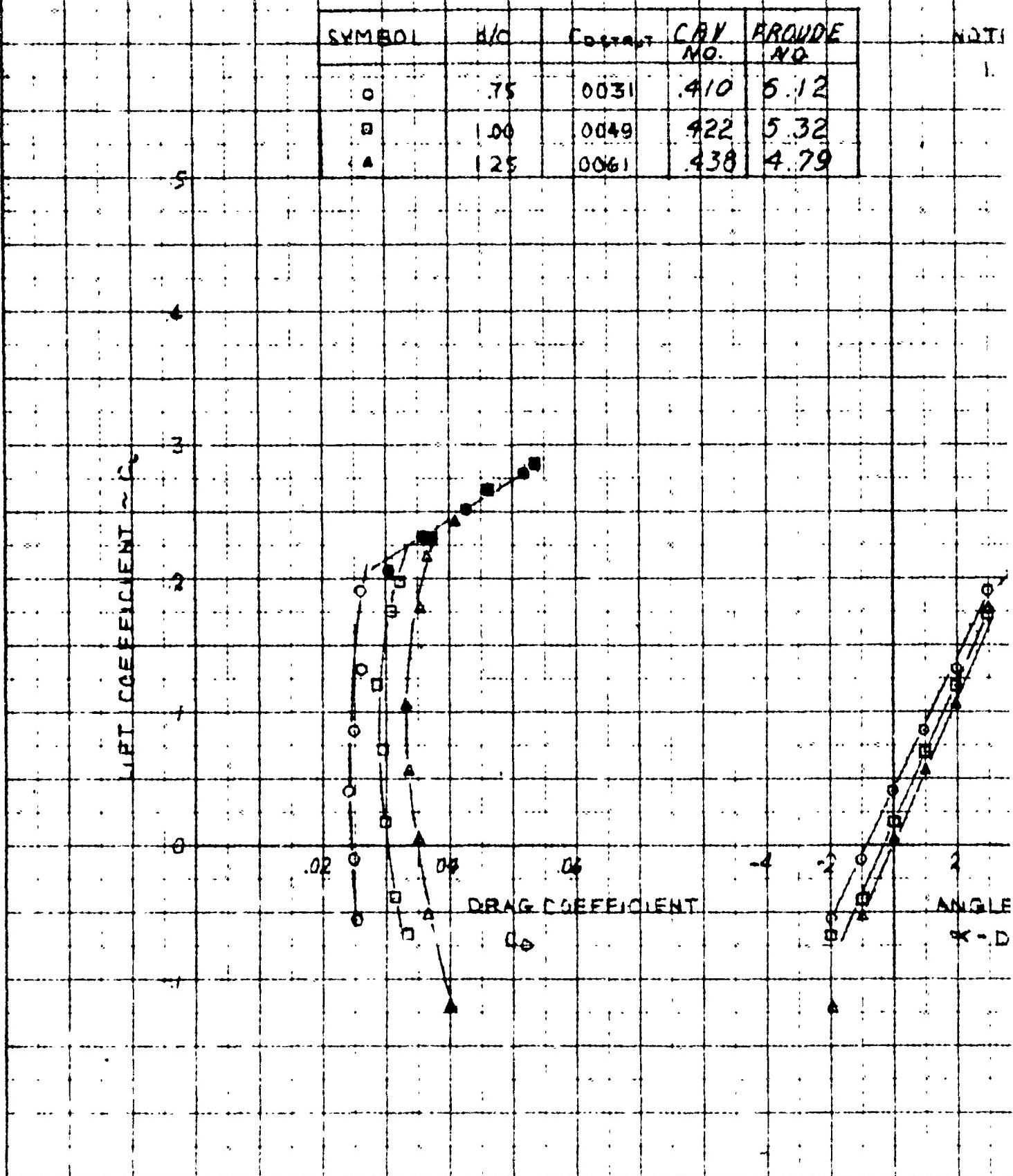
40 KTS

M.A.C. = 126 FT.

MARKED SYMBOLS INDICATE
VENTED FLOW



REPORT NO



GRUMMAN AIRCRAFT ENGINEER

PAGE IV.47

WALMING TANK TEST NO 223

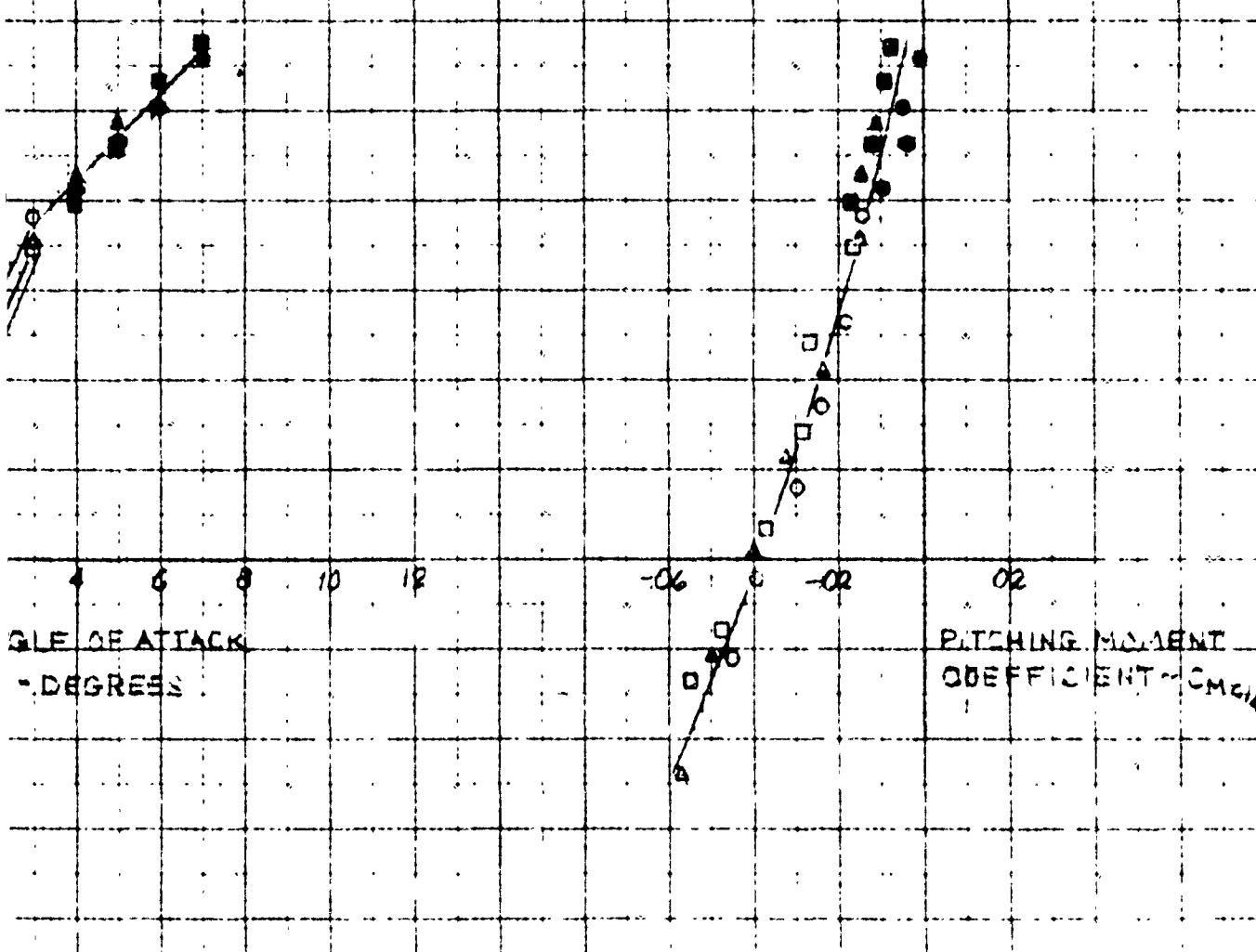
NO 01 94454

MODEL NG9

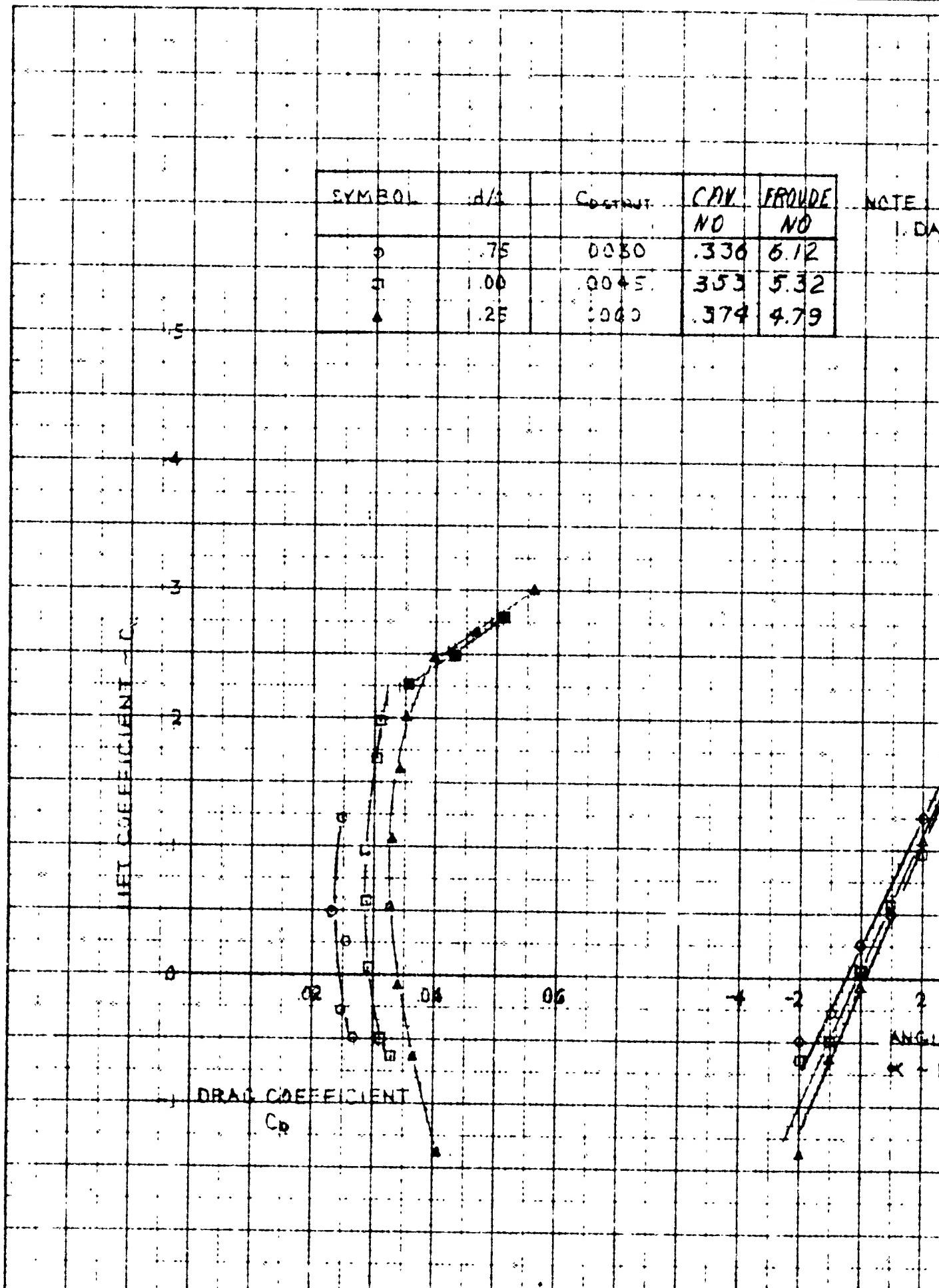
45 KTS

M.A.C. = 3.672 ft.

NOTE:
1. DARKENED SYMBOLS INDICATE
VENTED FLOW.



REPORT NO



GRUMMAN AIRCRAFT ENGINE

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WHIRLING TANK TEST NO 21E

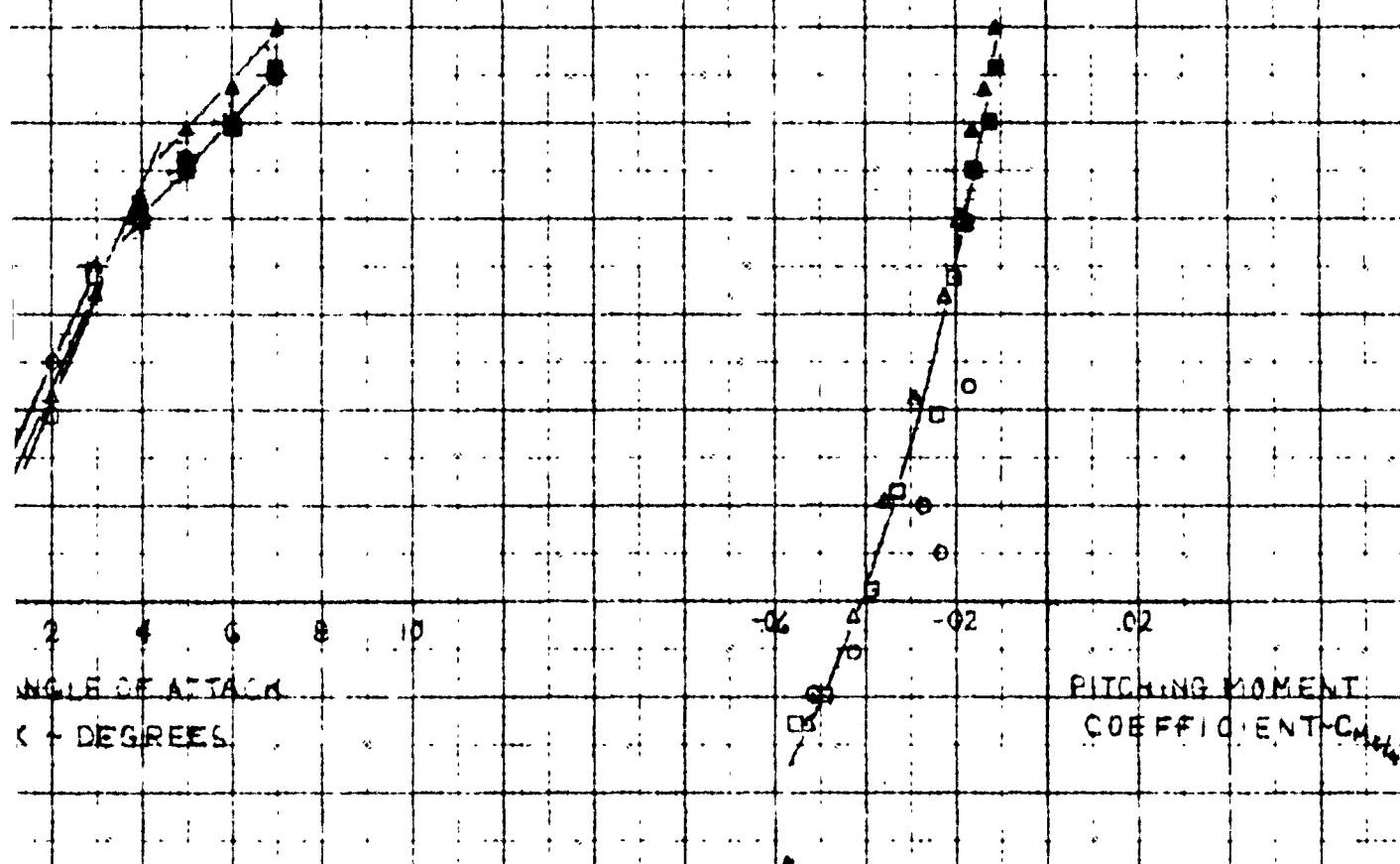
NO 6s B4-E4

MODEL NO 9

50 RPS

M.M.G. : 152 FT

DARKENED SYMBOLS INDICATE
VENTED FLOW



REPORT NO

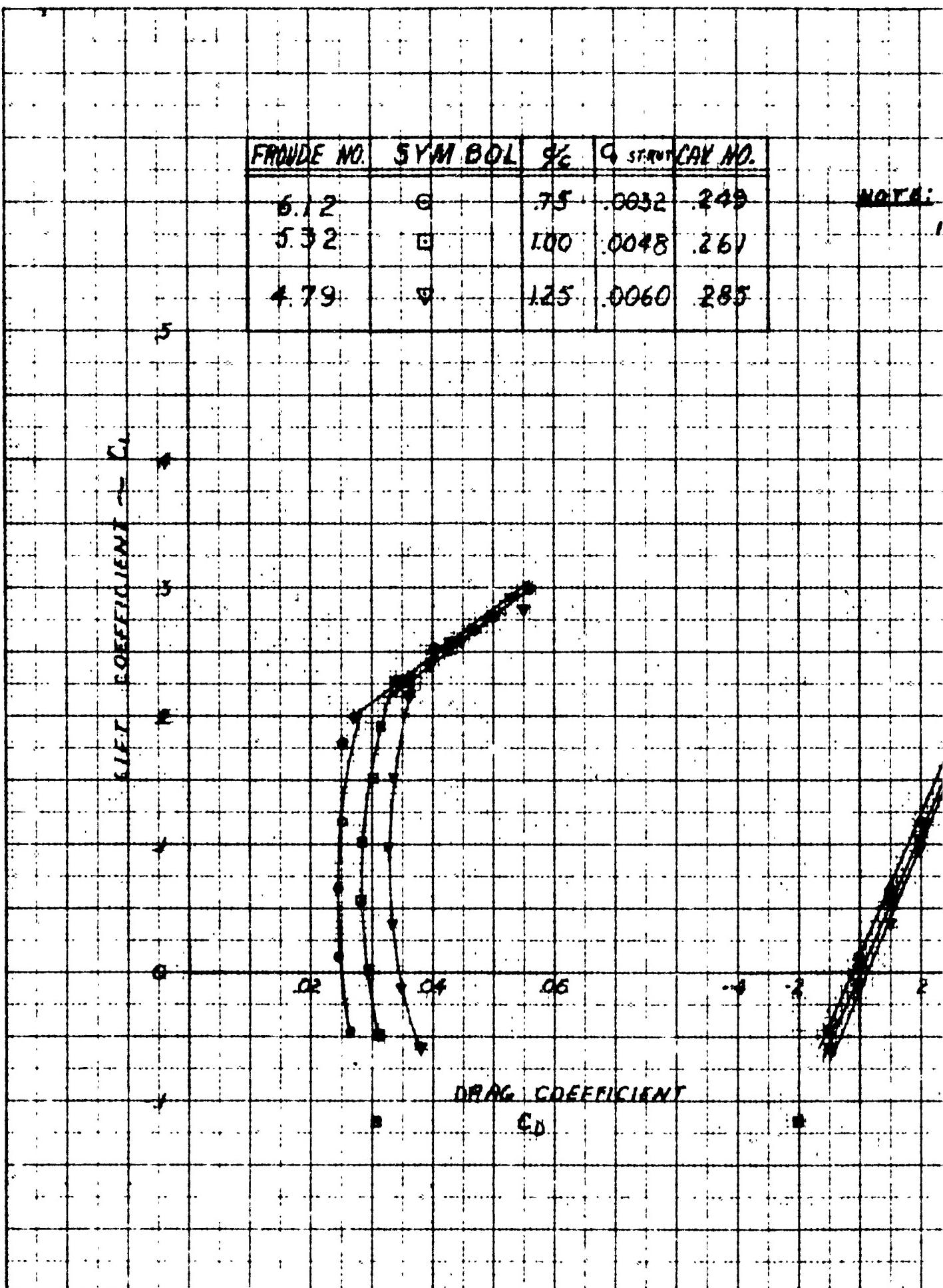
FRONDE NO.	SYMBOL	%	C _D	STRUCTURE NO.
------------	--------	---	----------------	---------------

6.12	G	.75	.0032	.249
5.32	D	1.00	.0048	.261
4.79	S	1.25	.0060	.285

JET COEFFICIENT - C_D

DRAG COEFFICIENT

C_D



GRUMMAN AIRCRAFT ENGINE

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WHIRLING TANK TEST NO. 205

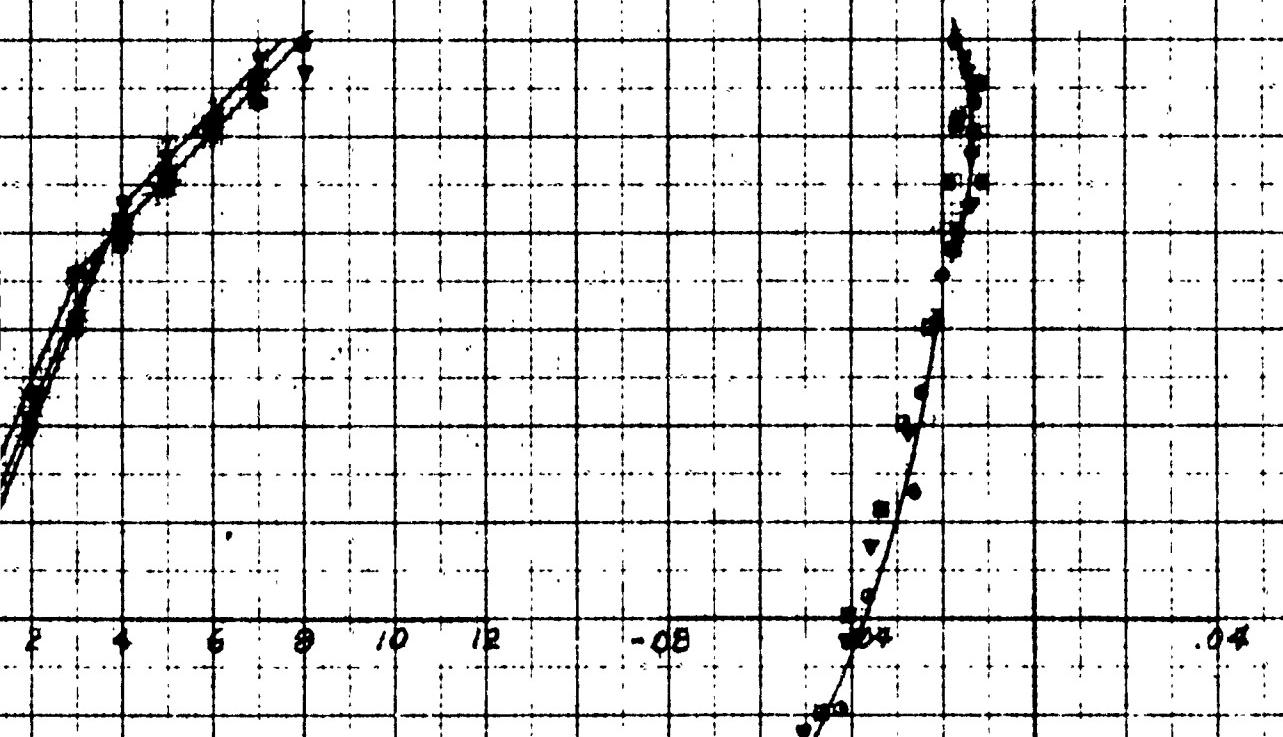
NO. 62 B4454

MODEL NO. 9

60 MTS.

MACH 7.156 FT.

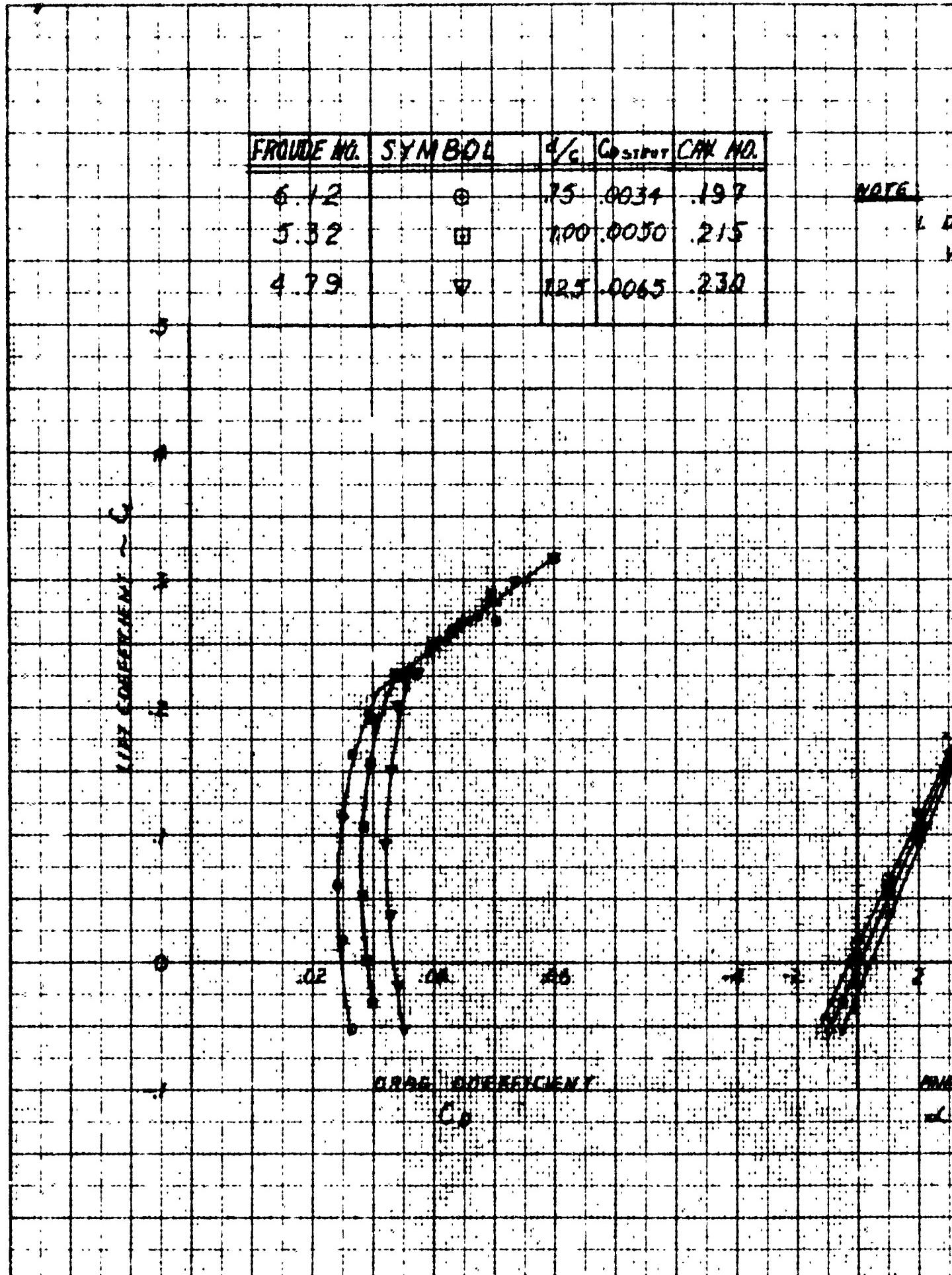
DARKENED SYMBOLS INDICATE
VENTED FLOW.



ANGLE OF ATTACK
α - DEGREES

PITCHING MOMENT
COEFFICIENT - C_{Mq}

REPORT NO



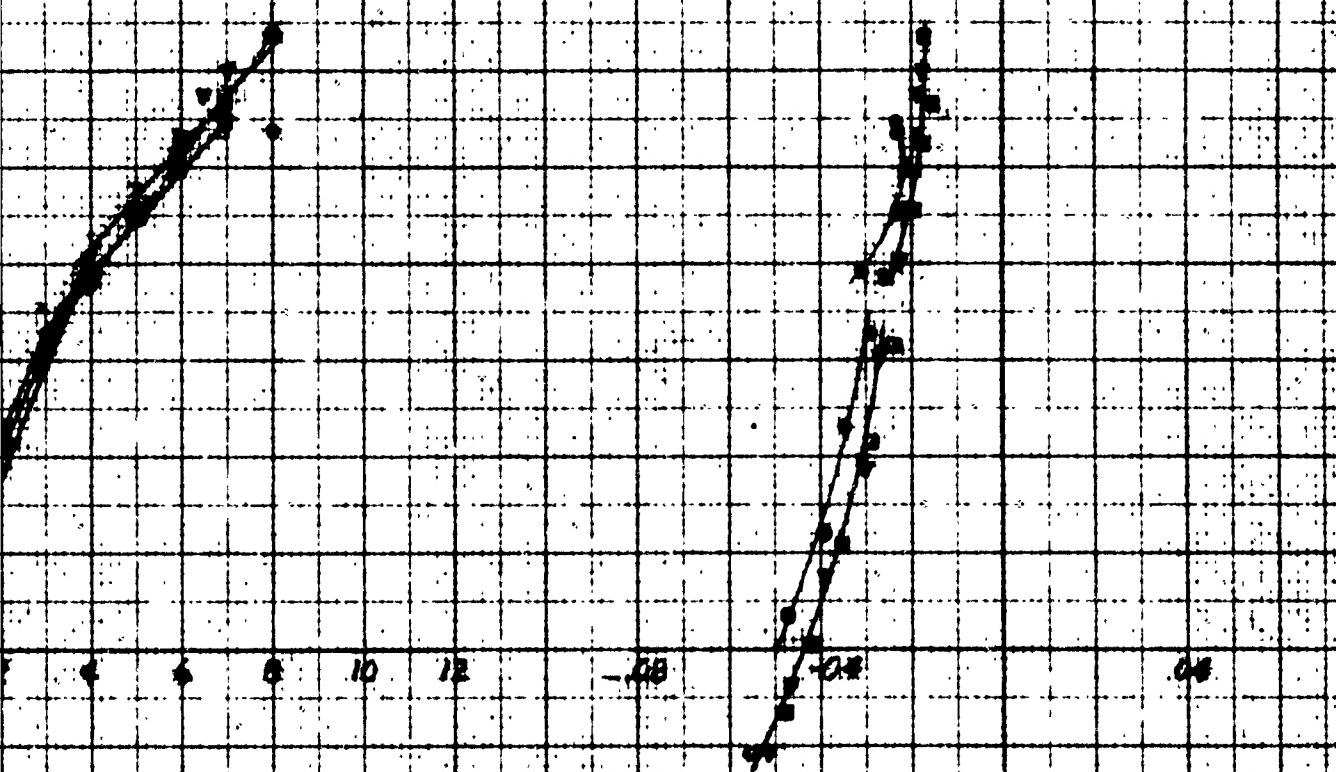
GRUMMAN AIRCRAFT ENGINEER

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WHIRLING TANK TEST NO. POE
NO. 6, B 9454
MODEL NO. 9

DOTTED SYMBOLS INDICATE
VENTED FLOW.

10 MTS.
MPC = 15.2 FT



ANGLE OF ATTACK
- DEGREES

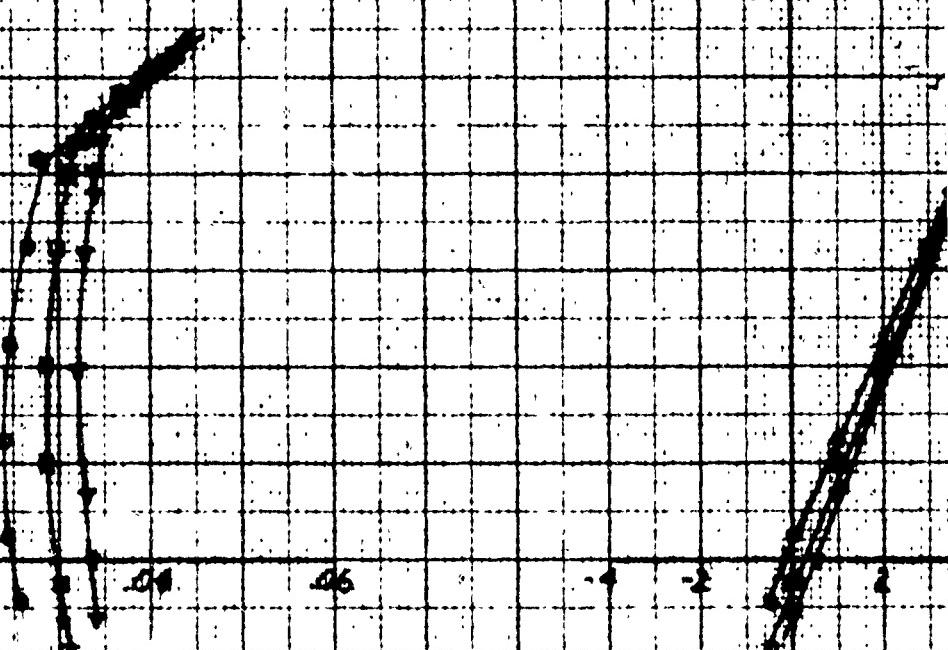
PITCHING MOMENT
COEFFICIENT - CM

REPORT NO

FRONDE NO. SYMBOL $\frac{1}{4}$ IN. CO. 10000 CAV. NO.

FRONDE NO.	SYMBOL	70°	100°	125°	W.E.
5.12	0	0004	1.77		
5.32	0	0051	1.97		
4.79	*	0067	2.10		

LIET COEFFICIENT - C_L



DRAG COEFFICIENT
 C_D

GRUMMAN AIRCRAFT ENGINEER

page 14.5 t

WHIRLING TANK TEST NO. 208

NO 05 B4954

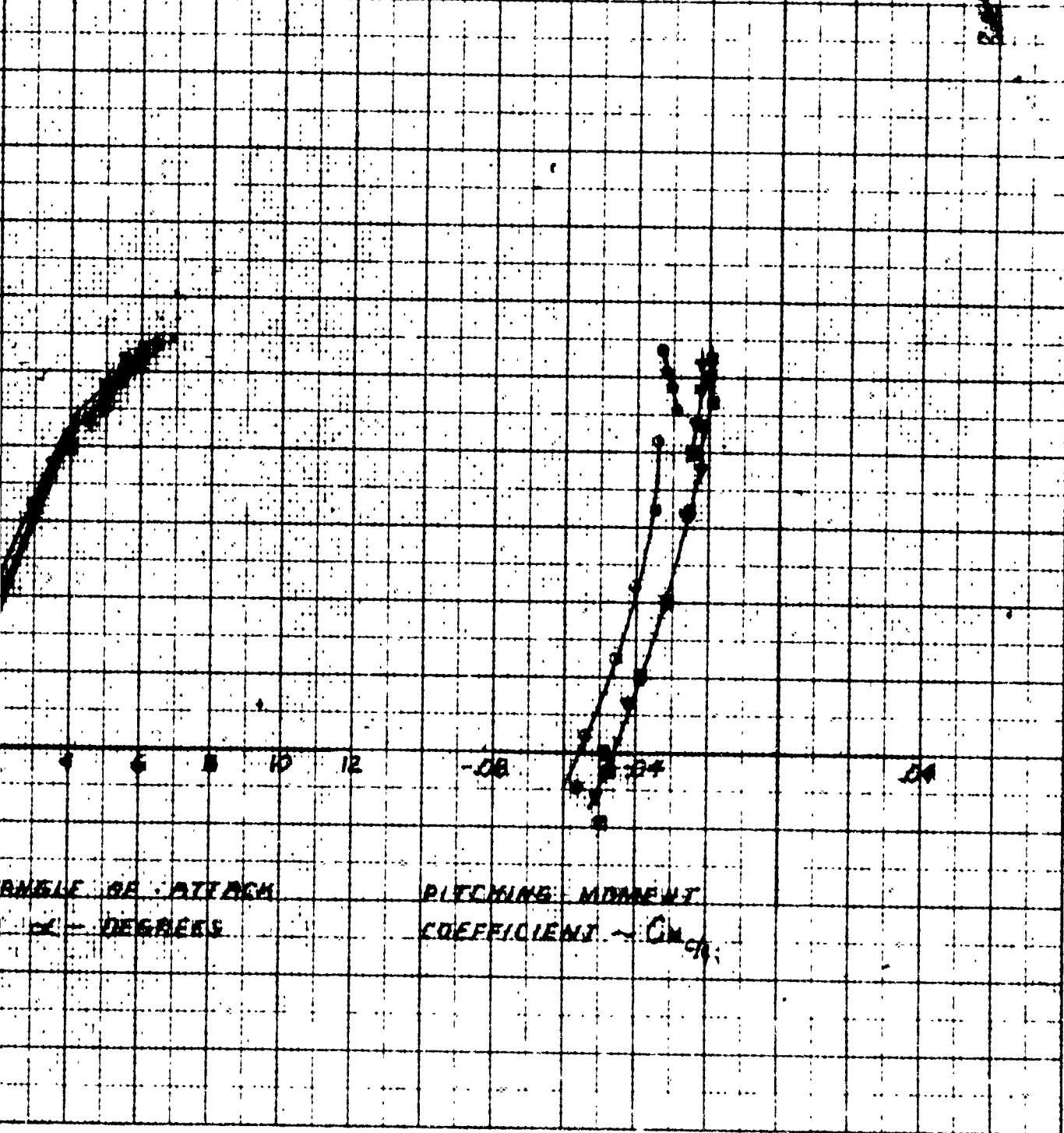
MODEL NO. 9

BO MTS

MAC = 152 FT

WATER

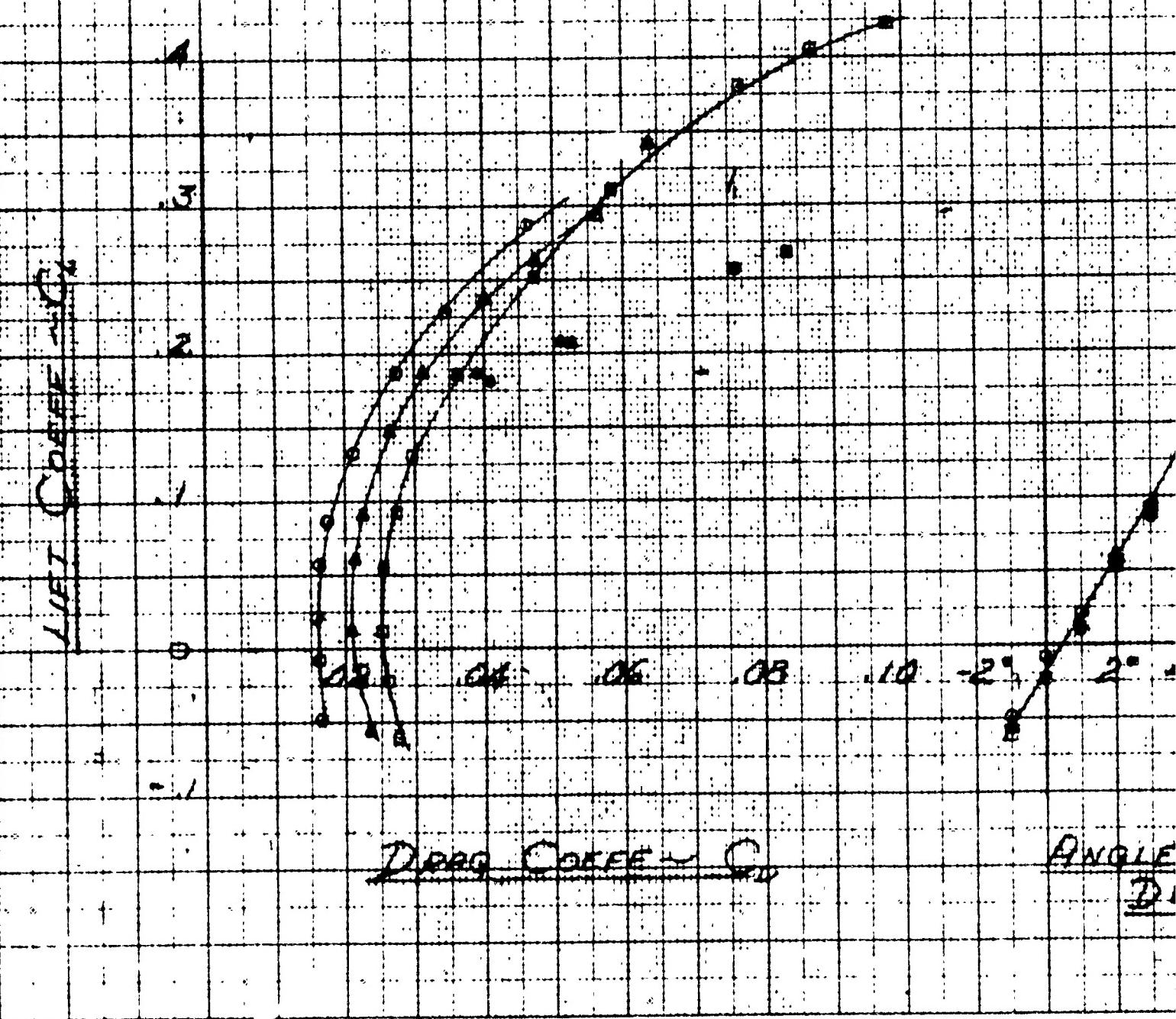
DARKENED SYMBOLS INDICATE
VENTED FLOW



REPORT NO

SYMBOL	d/c	FROUDE NO.	CAY. NO.
•	.75	5.0890	52695
•	1.00	4.4438	54879
•	.25	4.0002	57041

No.
1.D
1A



PAGE IV.5.2

WHIRLING TANK TEST NO. 39

BUSHIPS FOIL NO. 10

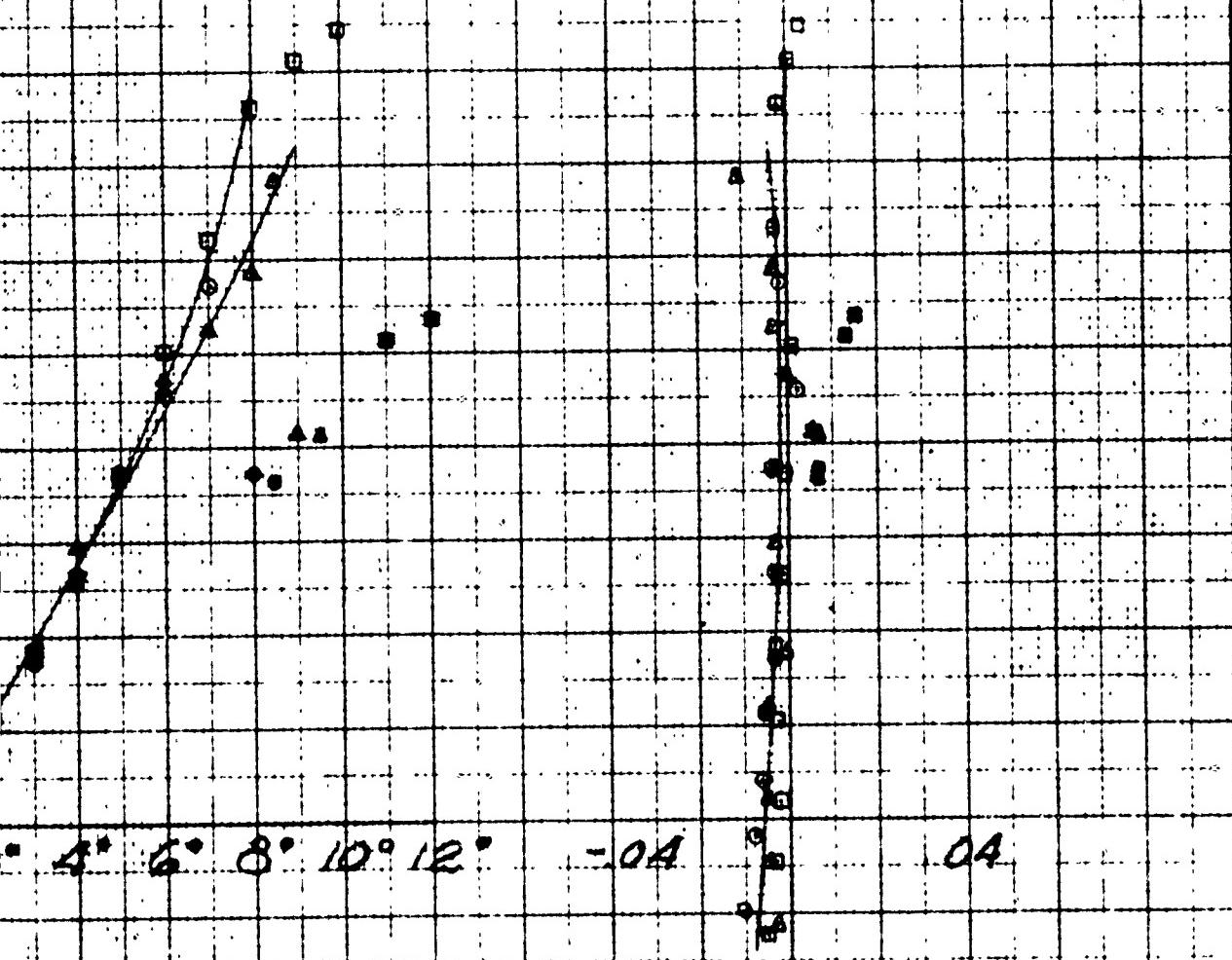
M.A.C. = 222 FT. ~ AREA = 3²"

V = 40 KNOTS

NOTE:

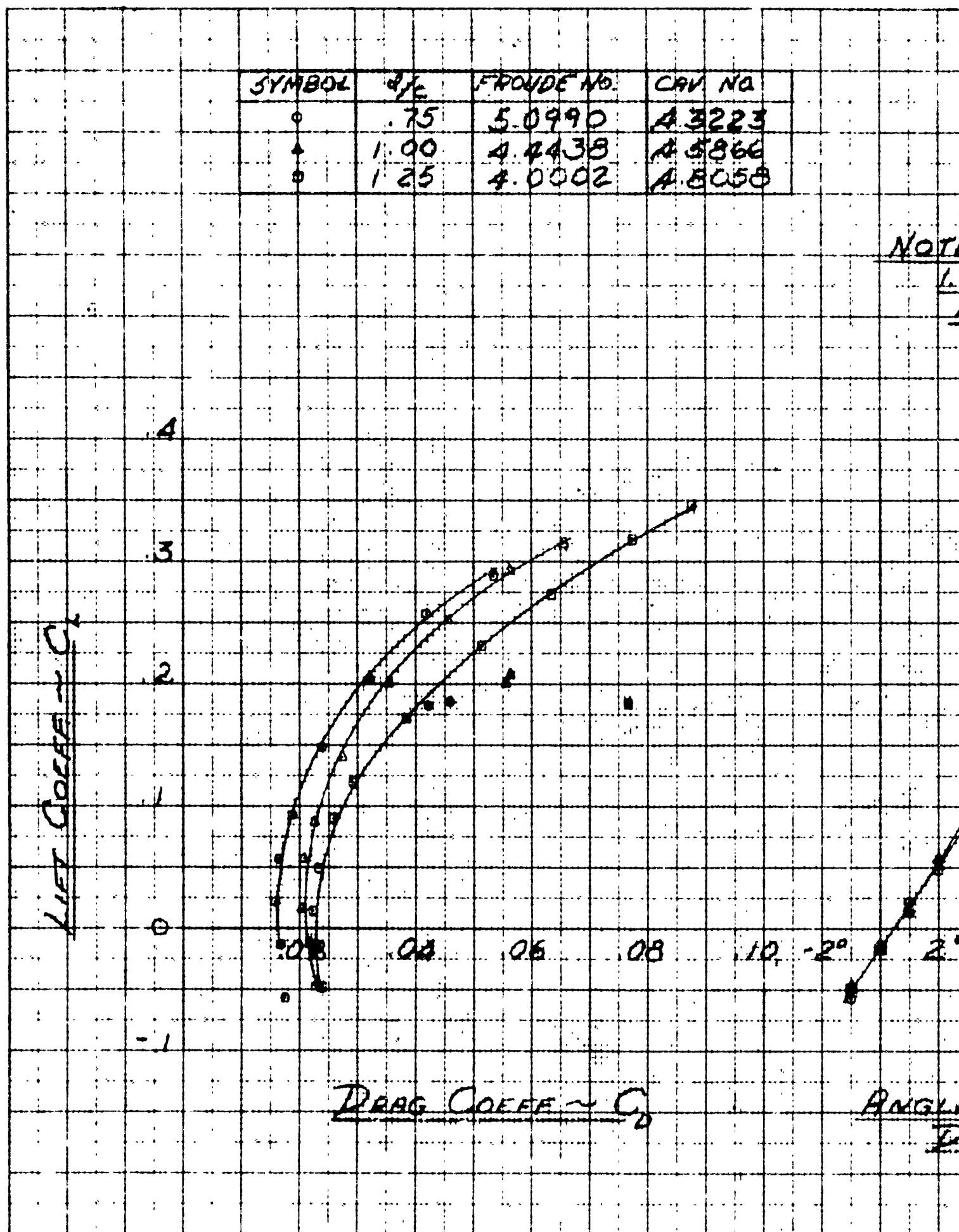
DARKENED SYMBOLS

INDICATE VENTED FLOW



ANGLE OF ATTACK
DEGREES

PITCHING MOMENT
COEFF. - C_m

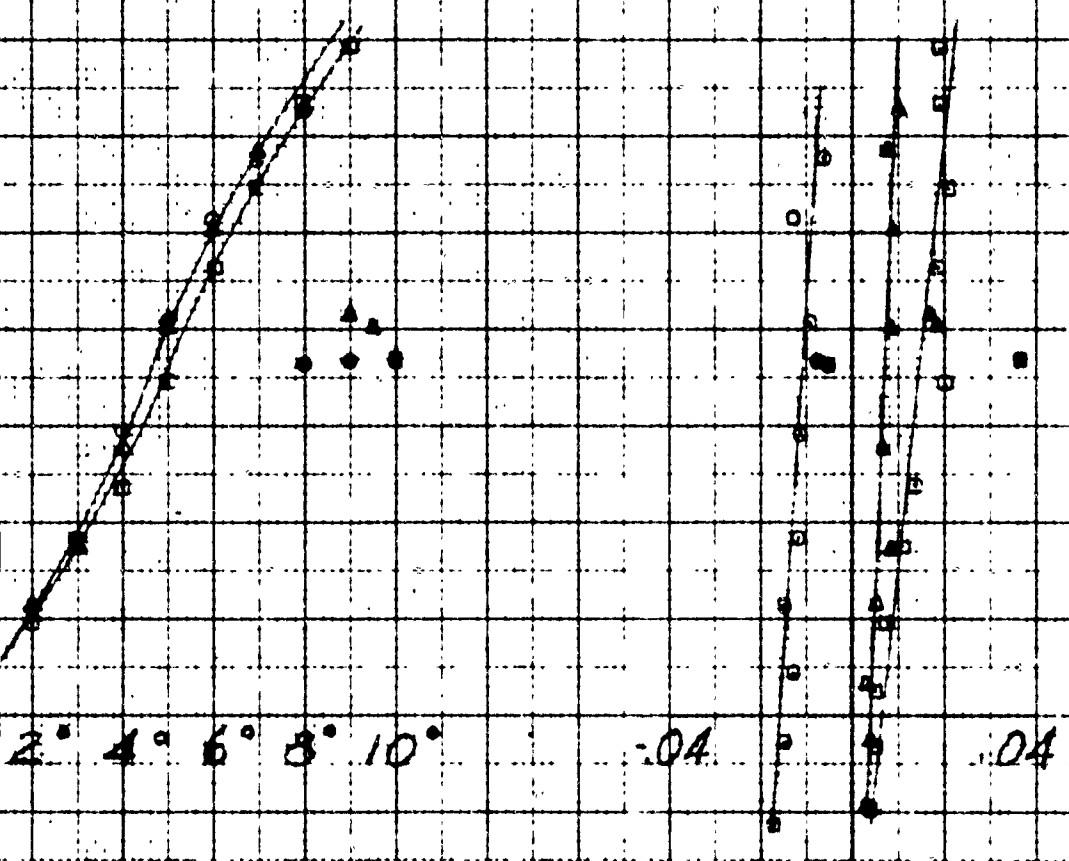


PAGE NO. 53

WHIRLING TANK TEST NO. 35
BU SHIPS FOIL NO. 10
M.A.C. = 822 FT - AREA = 8.9"
 $V = 45$ KNOTS

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.

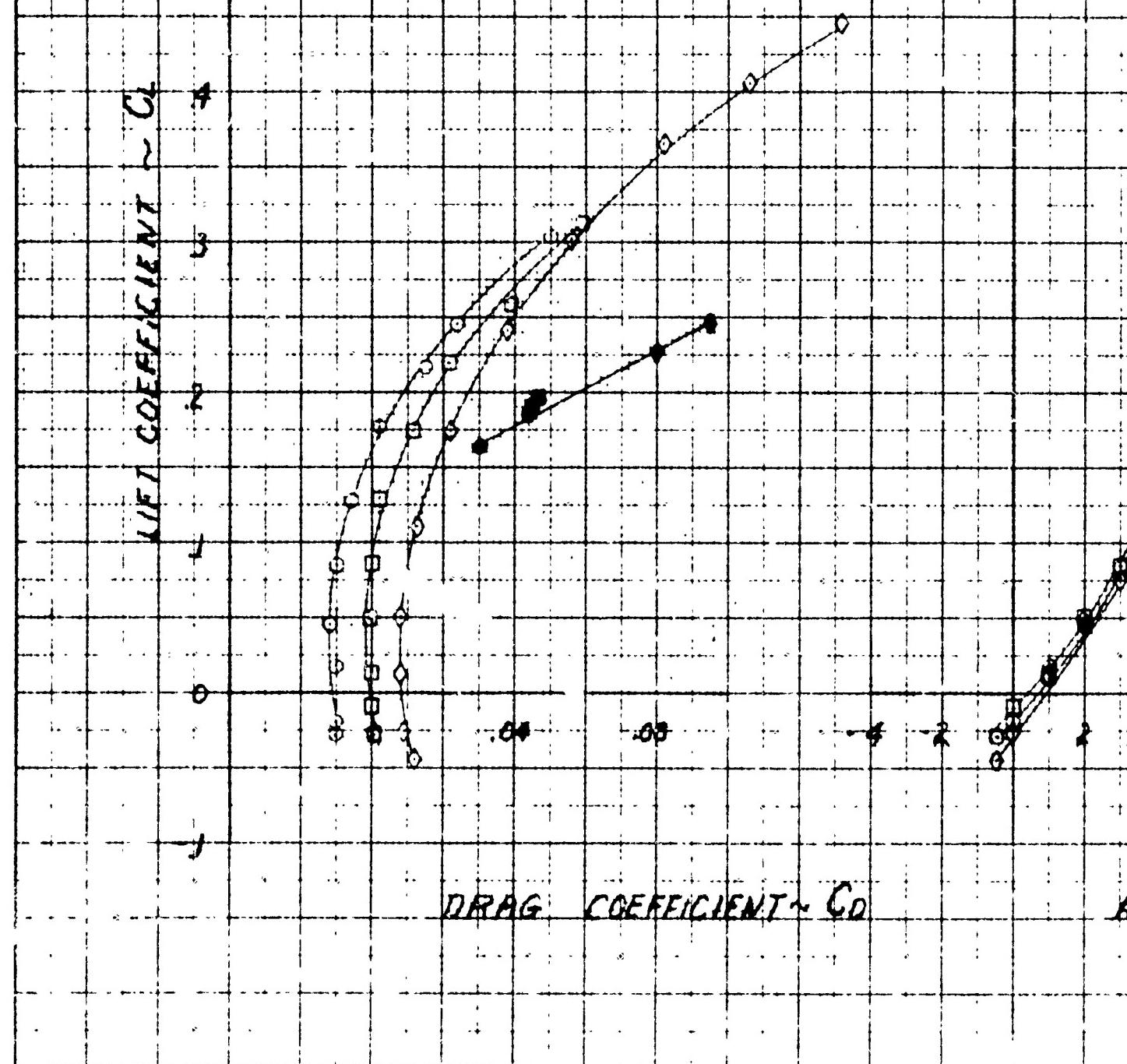


ANGLE OF ATTACK
DEGREES

PITCHING MOMENT
COEFF. ~ C_m

CAK NO	FRONDE NO	SYMBOL	DIMEN.
5.22	50271	○	75
7.46	43797	■	180
5.65	39414	◆	125

REF. SURFACE - E-H



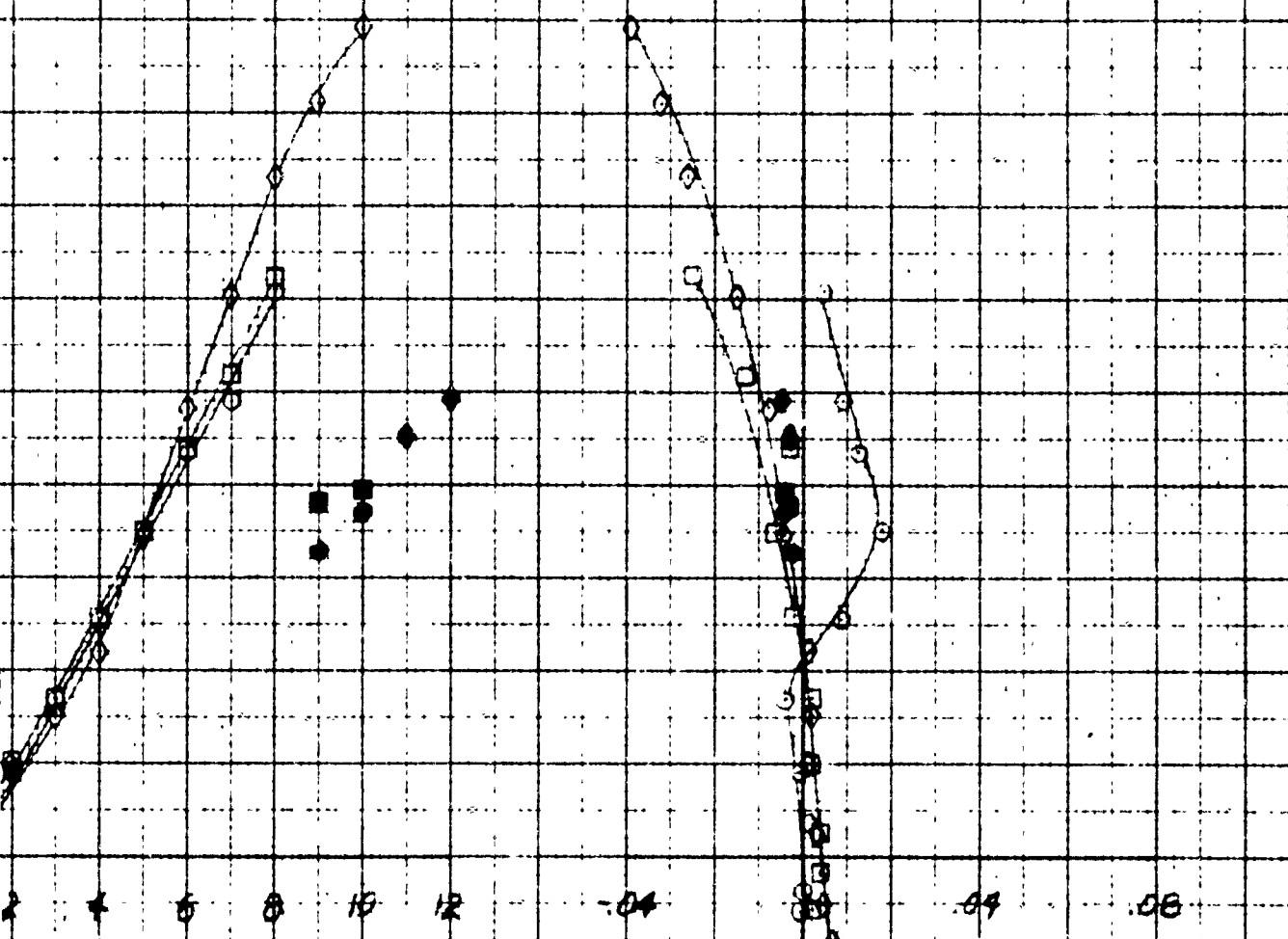
PAGE IV 54

WHIRLING TANK TEST NO 40
FOIL NO. 11 NAC = 0229 FE
AREA = 9.60 SQ IN.

V = 40 MTS.

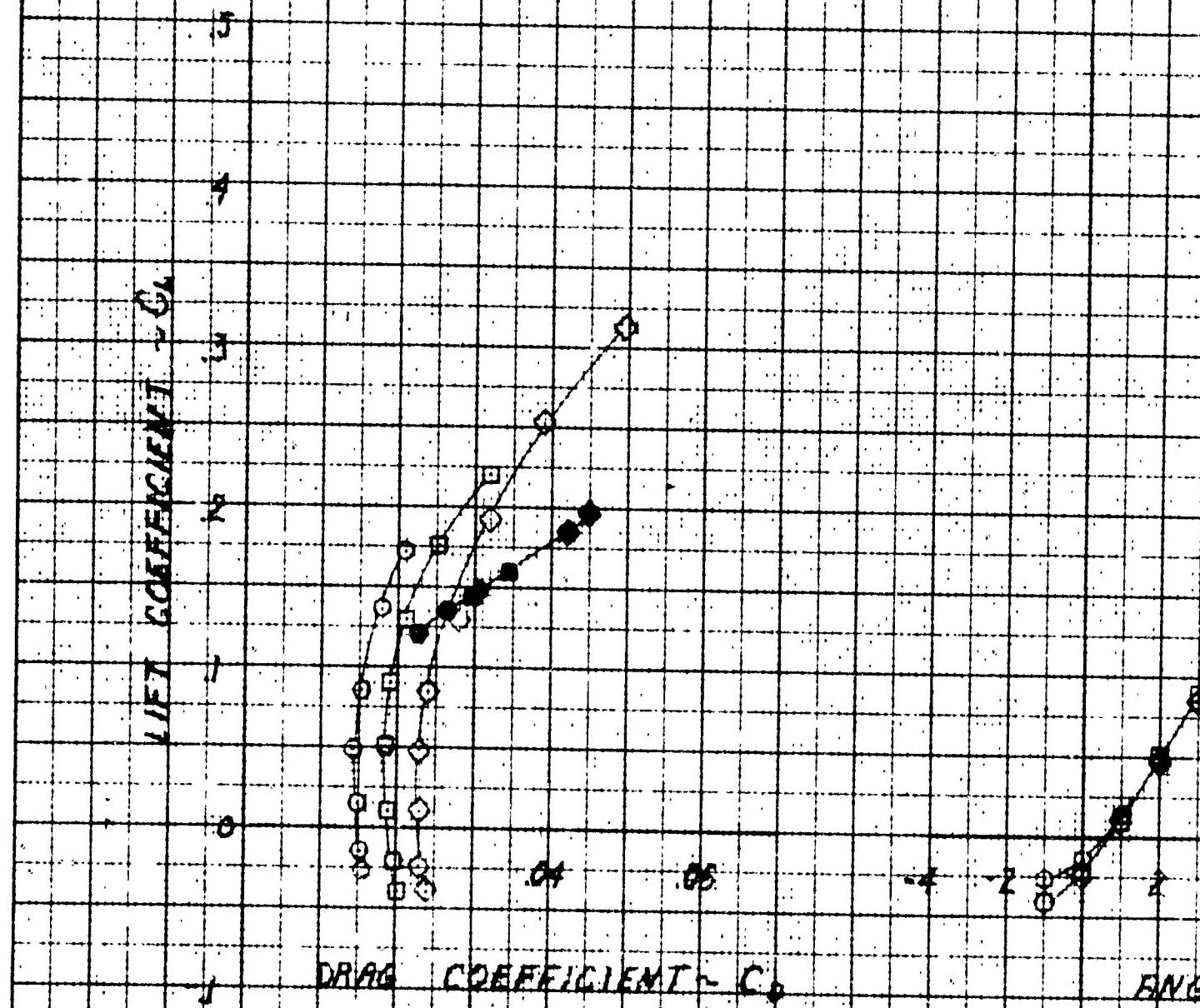
NOTE

1. DARKENED SYMBOLS
INDICATE VENTED FLOW



PITCHING MOMENT
COEFFICIENT ~ C_m

CAV NO	FRONDE NO	SYMBOL	d/MAC
429	50271	○	75
452	43797	■	100
479	39814	◆	125



LIFT COEFFICIENT ~ C_L

DRAg COEFFICIENT ~ C_D

NACA

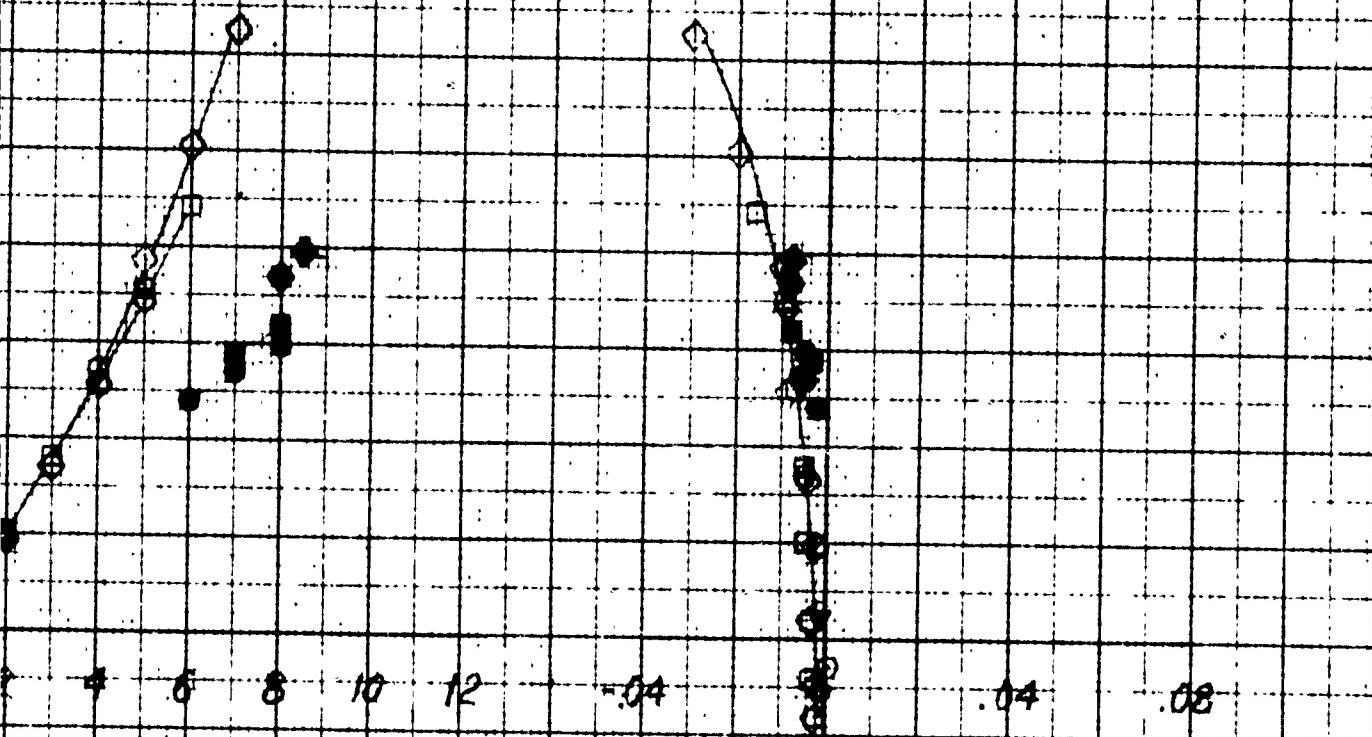
PAGE 1455

WHIRLING TANK TEST NO. 40.
FQ14 NO 11 MAC = 0.229 FT.
AREA = 0.60 SQ. IN.

V = 45 M/S

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.



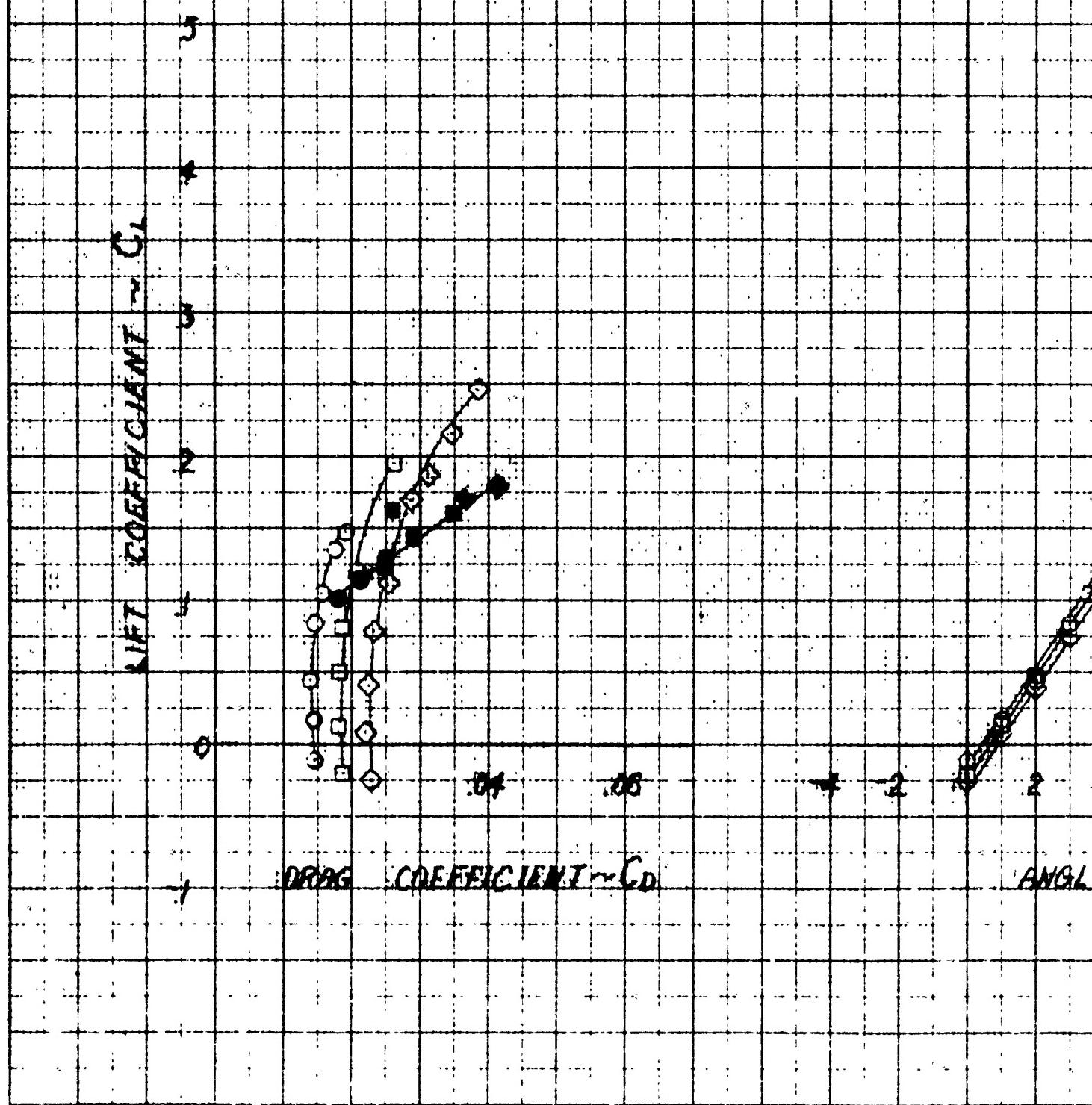
ANGLE OF ATTACK - 56 DEGREES

PITCHING MOMENT
COEFFICIENT - C_m

CAH M2	FRONTSIDE M2	SYMBOL	d / INCH.
3.63	50271	○	.75
3.88	43797	□	1.00
4.12	35414	○	1.25

NOT

TEST INSTRUMENTS INC.
1951 INSTRUMENTS INC.



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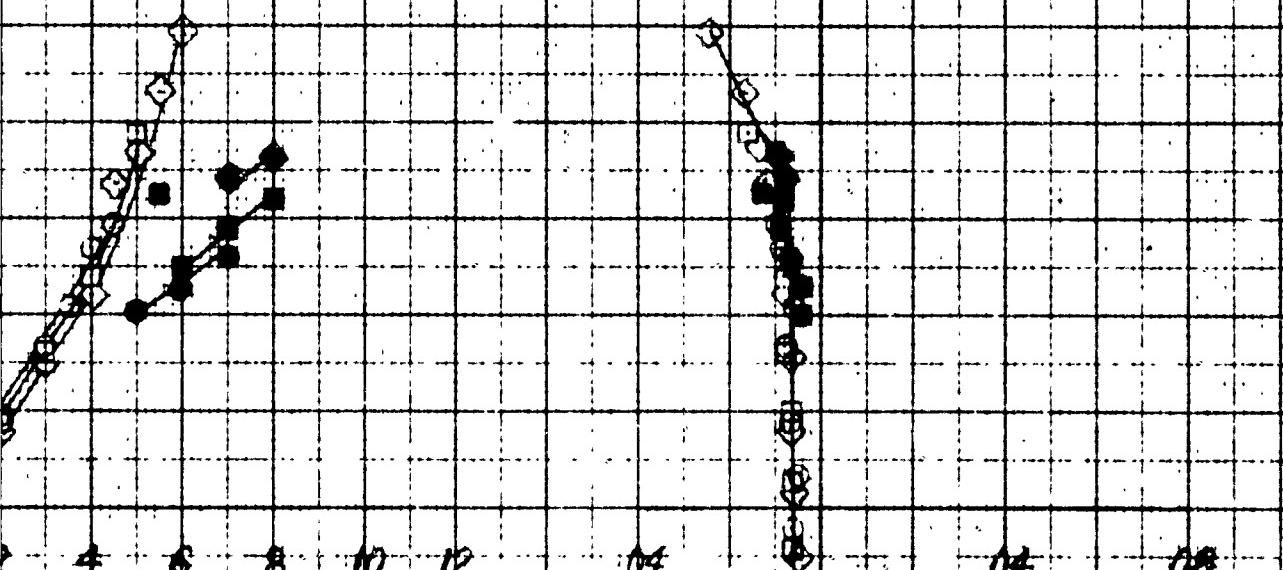
WATERLINE TANK TEST NO. 40

EGIL NO. 11 MAC = 0.229 FT
AREA = 9.60 SQ IN.

$V = 50 \text{ KTS.}$

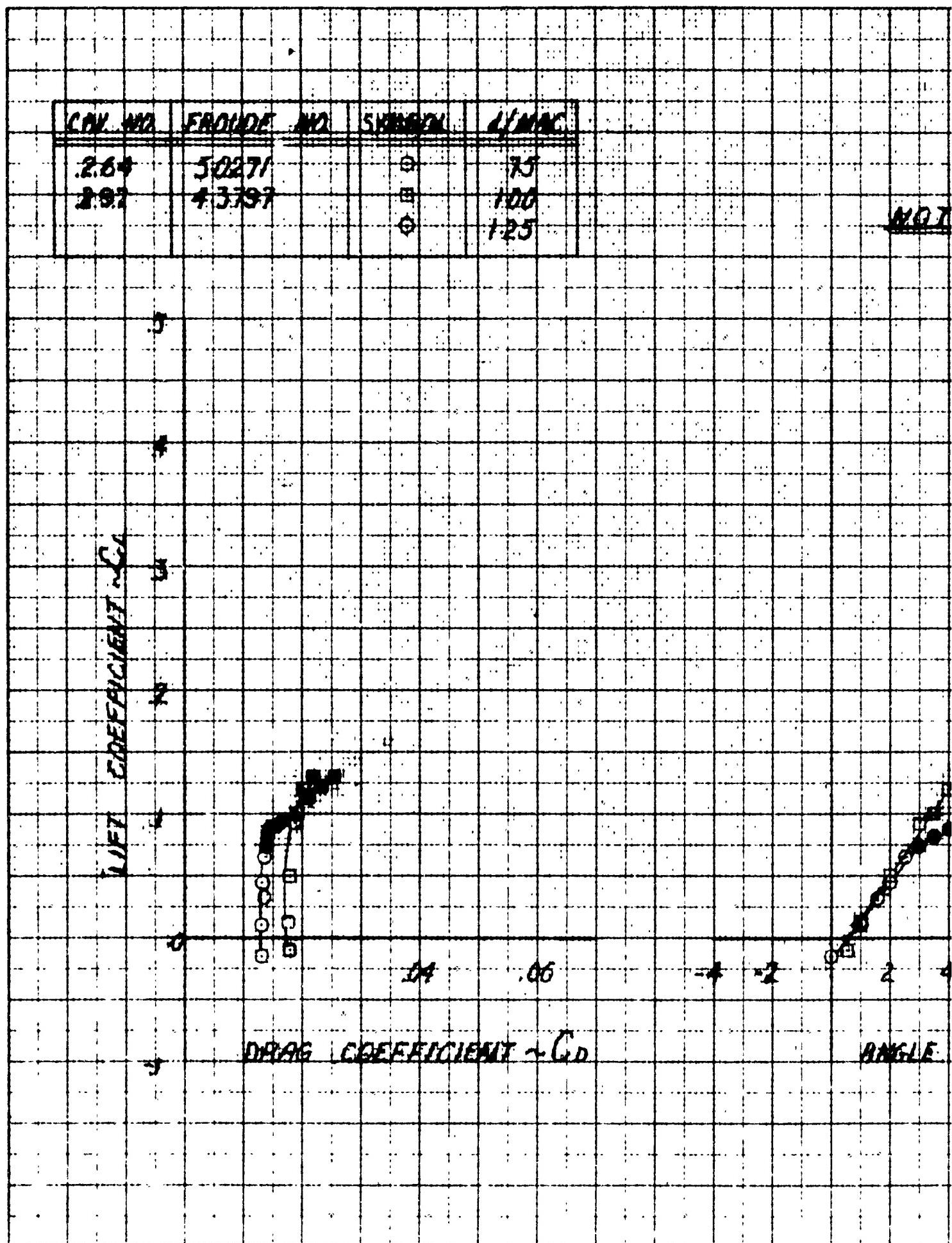
NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.



ANGLE OF ATTACK - α - DEGREES

PITCHING MOMENT
COEFFICIENT - C_m - $\frac{1}{4}$



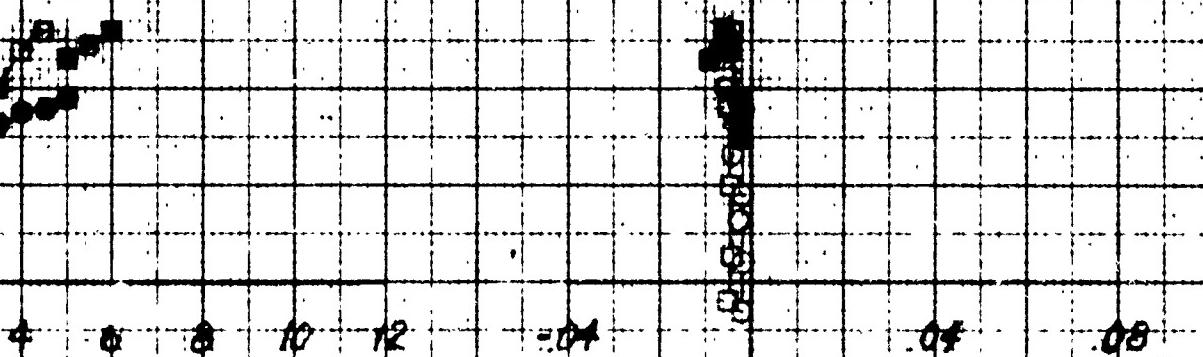
PAGE 1657

WHIRLING TANK TEST NO. 40
FOIL NO. 11 MAC = 0.229 FE
AREA = 9.50 SQ IN

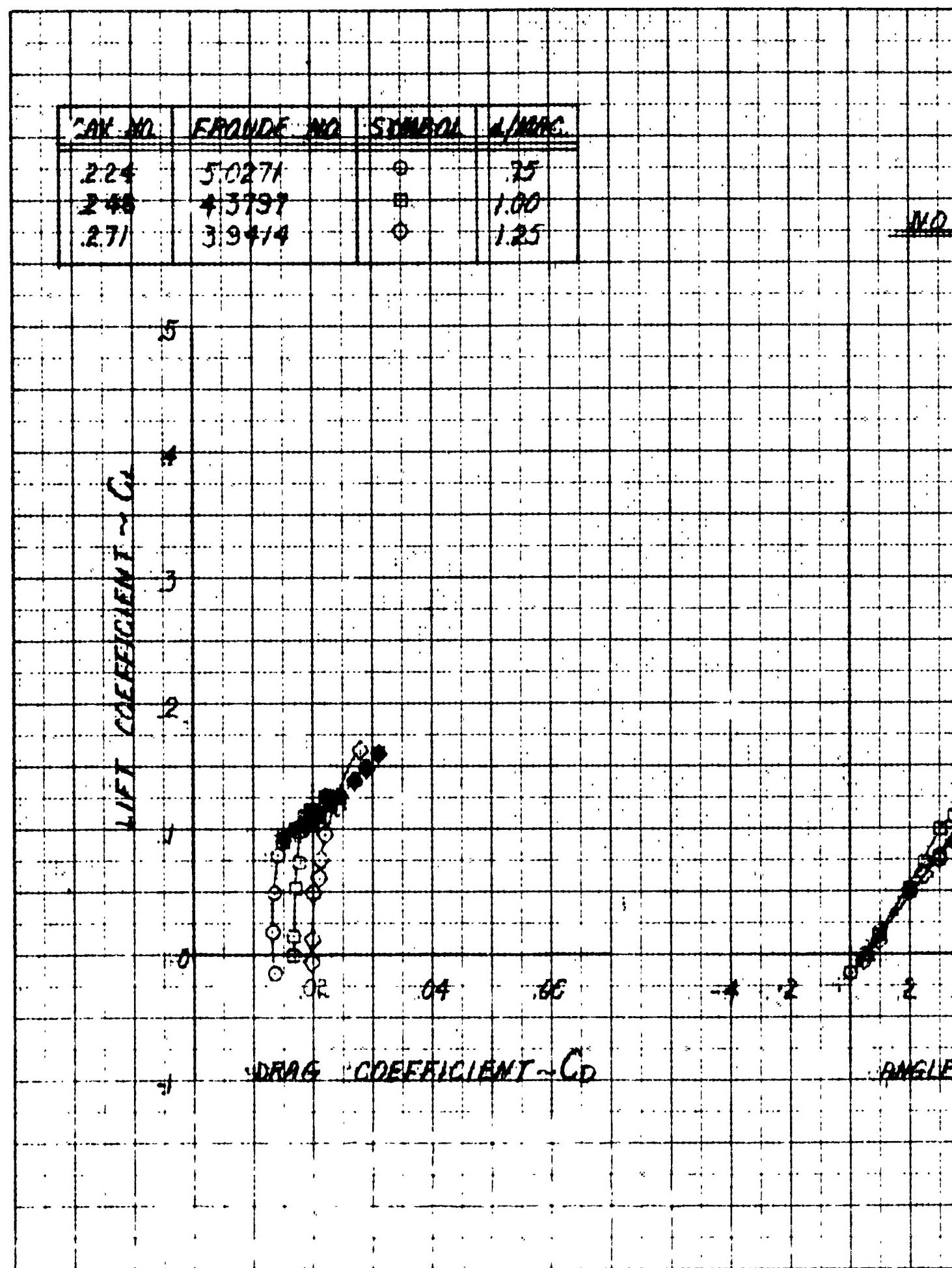
8 = 60 KTS

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.



PITCHING MOMENT
COEFFICIENT - C_m -



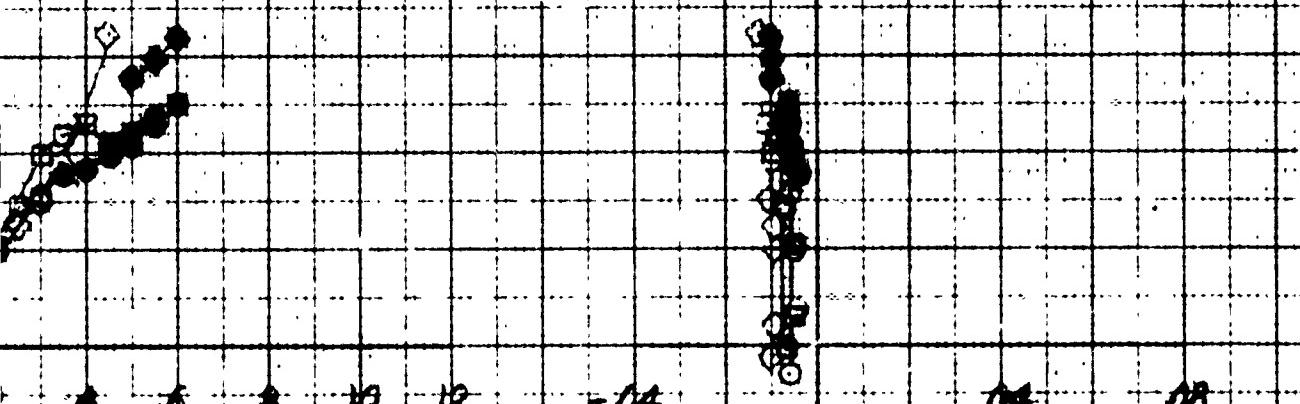
PAGE 1450

WHIRLING TANK TEST NO. 40
EDD NO. 11. MRC = 0.229 FT.
AREA = 3.60 SQ. FT.

V = 70 KTS.

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.



ANGLE OF ATTACK ~ α ~ DEGREES

PITCHING MOMENT
COEFFICIENT ~ C_m

CAV NO FLOWDE NO STREAMLINE

.130 50271 0 75

NOTE

2-182 TWO STATION 3M

WET COEFFICIENT - C_w

5

4

3

2

1

0

DRAG COEFFICIENT - C_D

ANGLE

0° 10°

-2° 2°

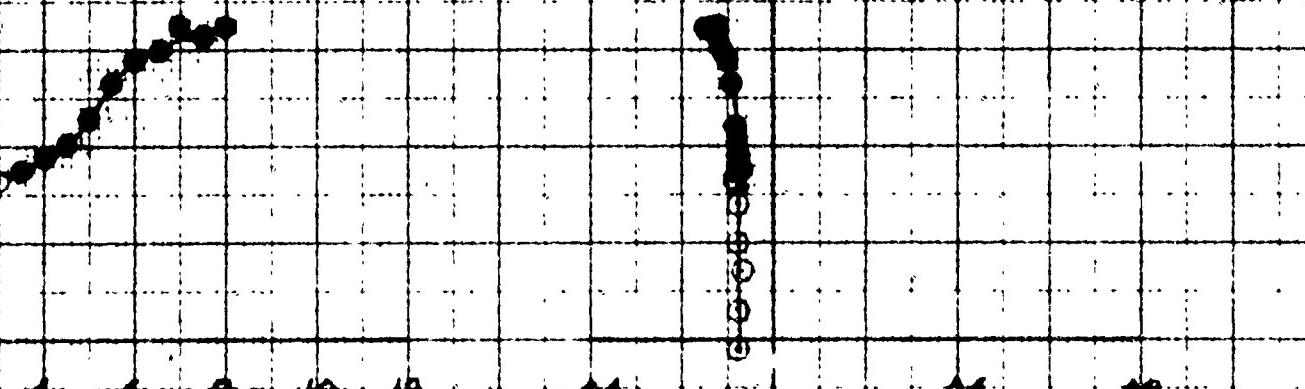
PAGE IV.59

WHIRLING TANK TEST NO. 40
FOIL NO. IV MAC = 0.229 FT.
ARER = 9.6050 IN

V = 80 MTS.

DARKENED SYMBOLS
INDICATE HEATED FLOW.

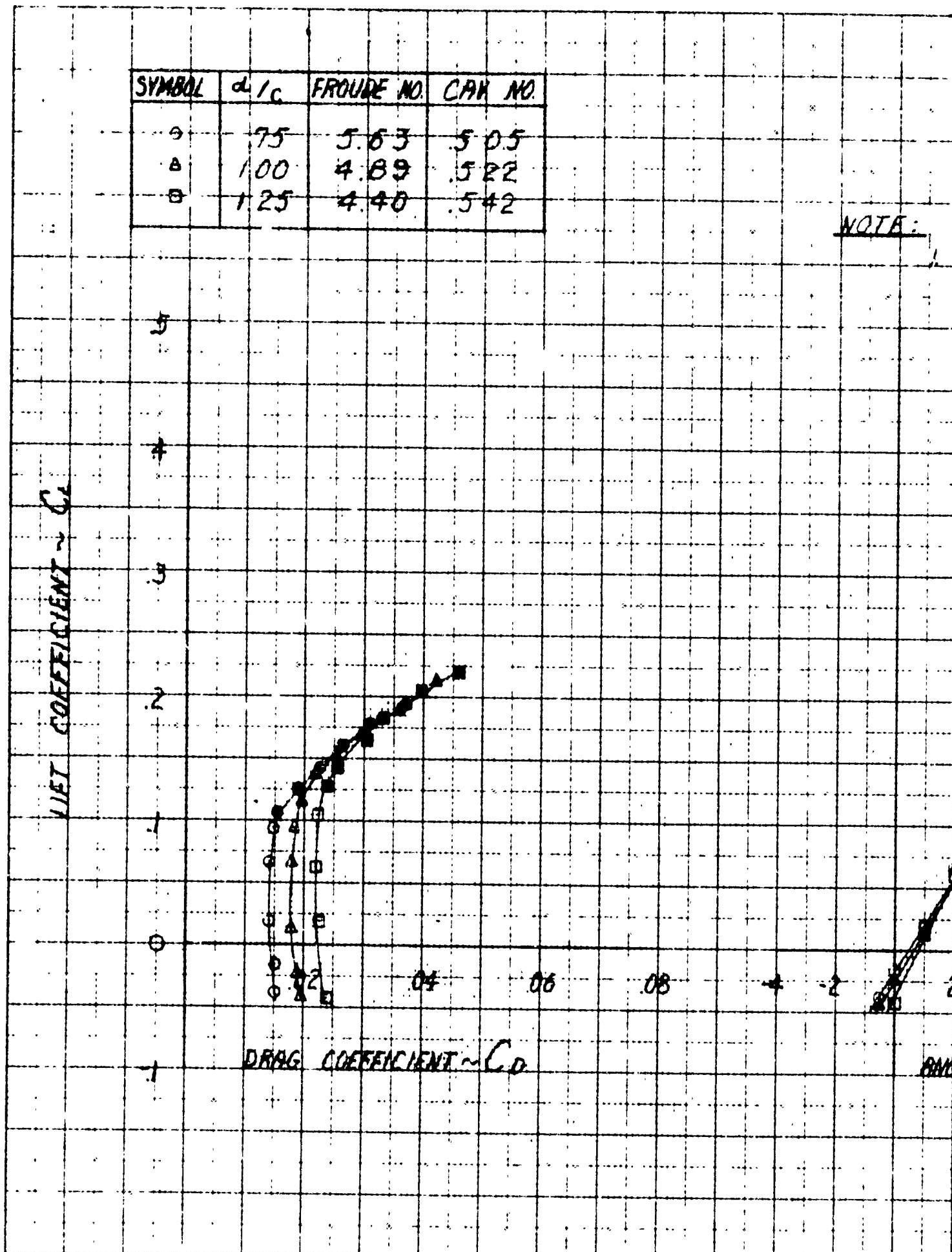
C. MODEL FAILED AT $\alpha = 8^\circ$



-6 -7 -10 -12 -14 -14 08

LE OF ATTACK - α - DEGREES

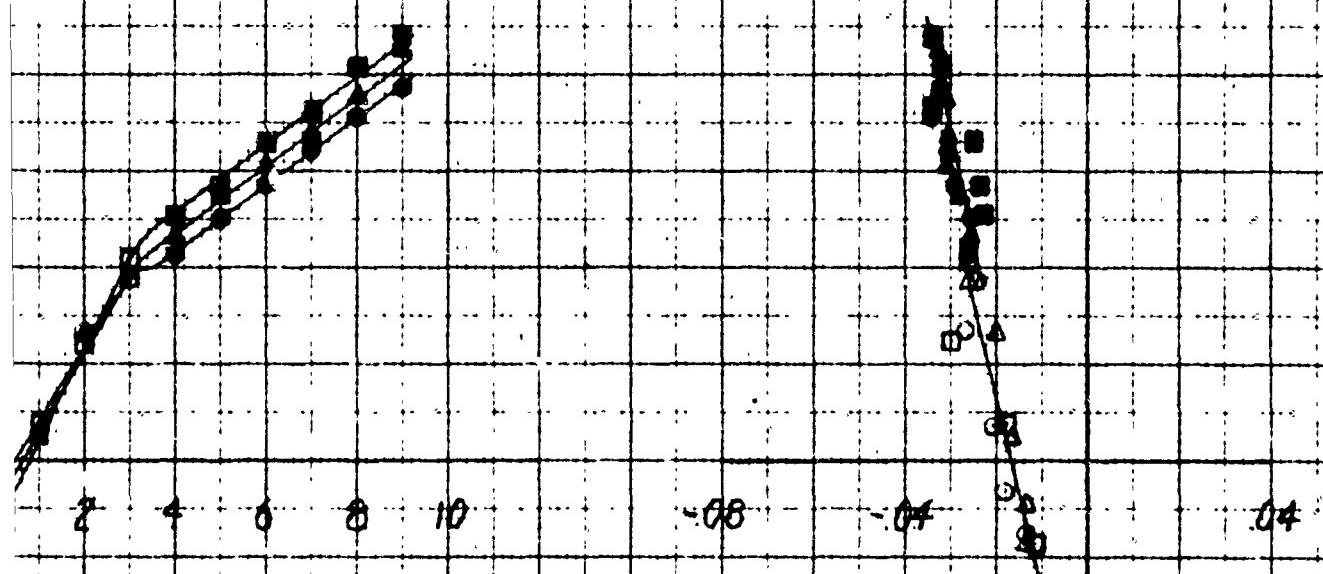
PITCHING MOMENT
COEFFICIENT - C_{M_C}



PAGE IV.60

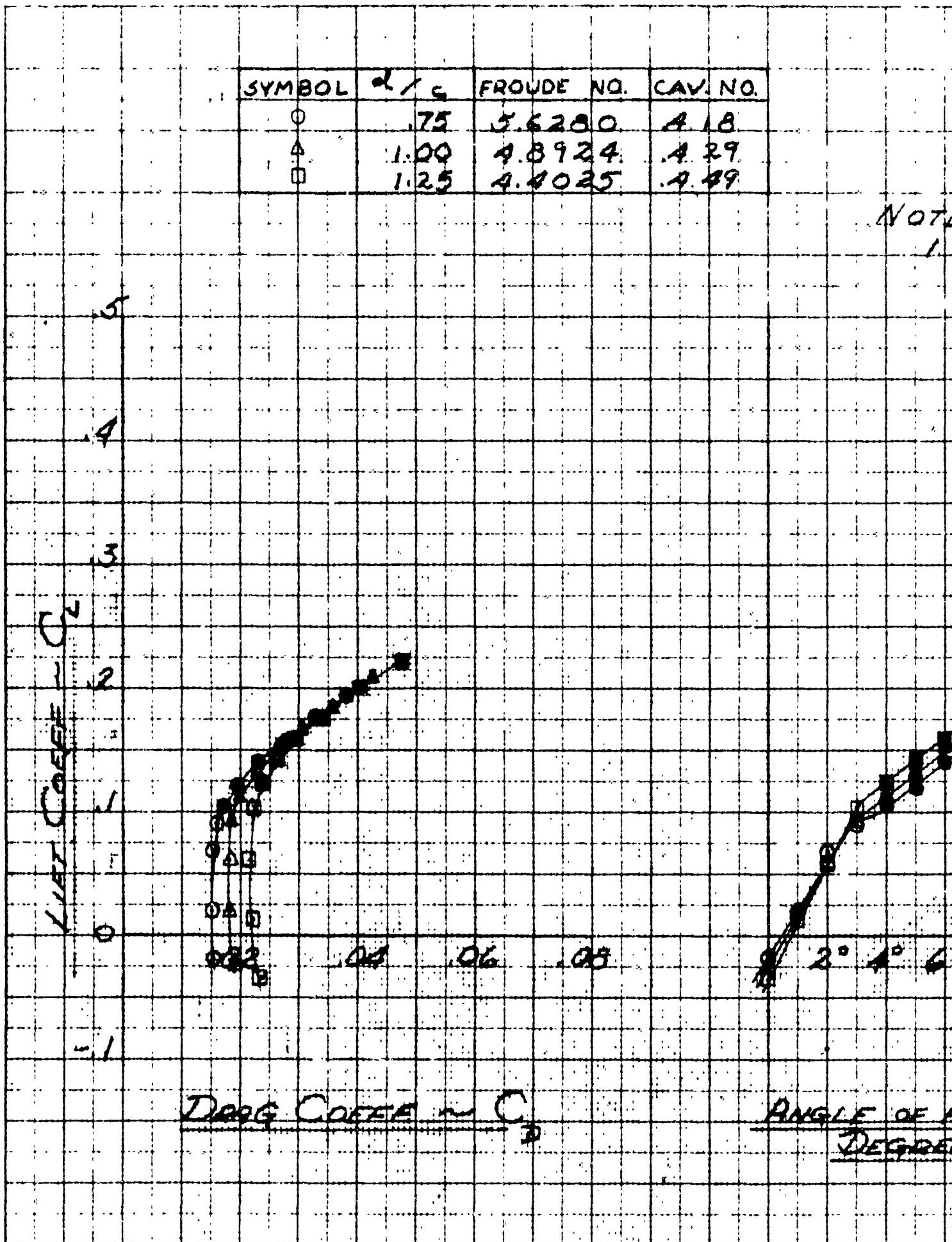
WHIRLING TANK TEST NO. 51
BU SHIPS FOIL NO. 12
M.A.C. = 182 FT ; S = 8.00 m^2
V = 40 VTS.

DARKESED POINTS
INDICATE PENTED FLOW.



ANGLE OF ATTACK ~ α DEG.

PITCHING MOMENT
COEFFICIENT ~ C_M

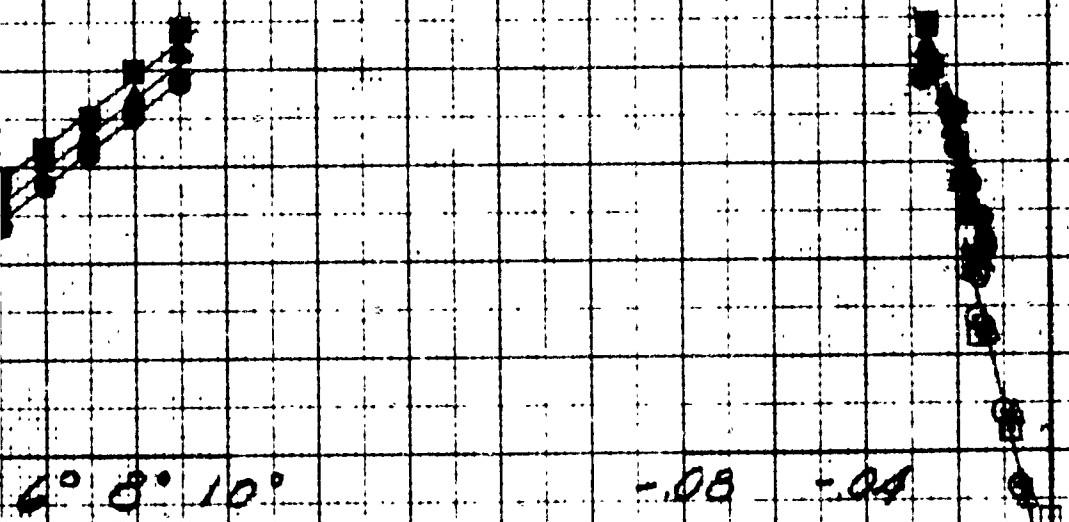


PAGE 14.61

WT.T NO. 31 PUSHIPS FOIL NO. 12
M.A.C. = .182 FT. AREA = 8.0 ft^2
VEL = 45 KTS

NOTE:

1) DARKENED SYMBOLS
INDICATE VENTED FLOW.



4° 8° 10°

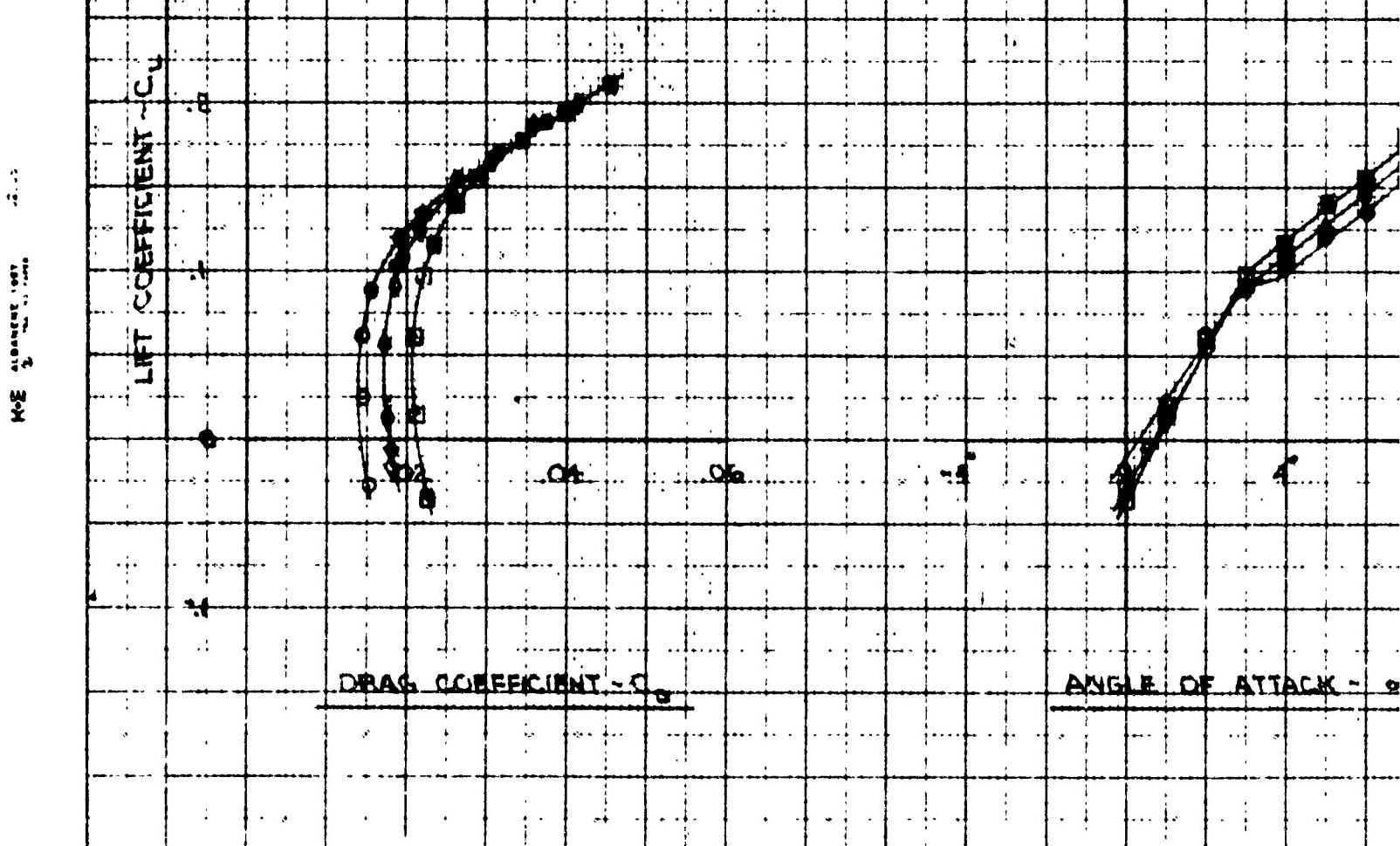
-08 -04

ATTACK
DEGREES

PITCHING MOMENT
COEFF = $C_m \frac{1}{4}$

WHIRLING TANK TEST NO. 51
BU SHIPS FOIL NO 12
MUL. = .182 HT S = 3.00 SQ.
VELOCITY = 5 G KTS

SYMBOL	d/c	FRAME	CAV
	NO.	NO.	NO.
O	.75	5.63	.5.00
*	1.00	4.89	.3.65
M	1.35	4.49	.3.89

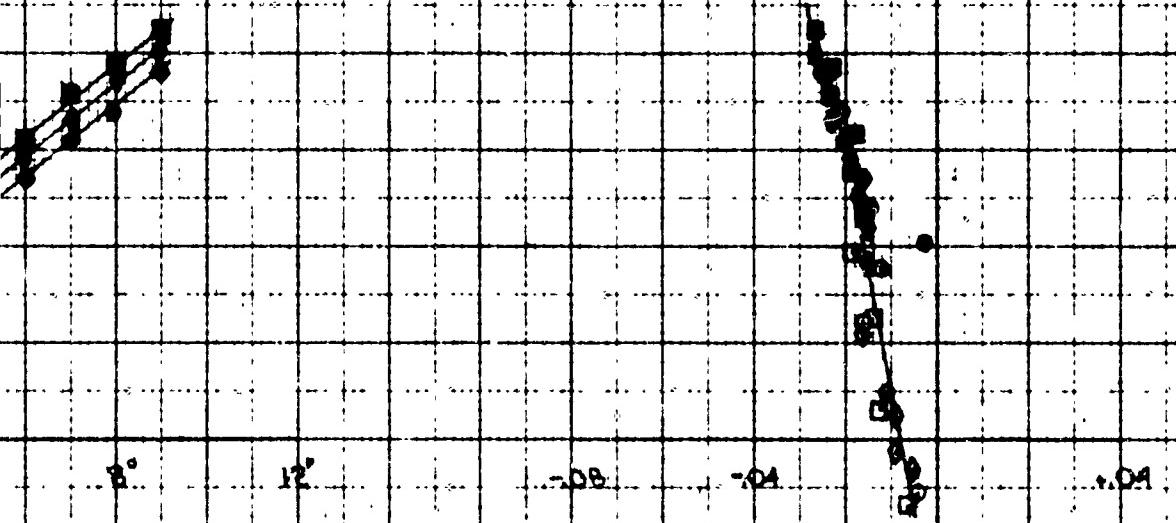


0.51

SQ. IN.

PAGE IV.6.2

NOTE: DARKENED POINTS INDICATE VENTED FLOW



-0.08 DEGREES PITCHING MOMENT COEFFICIENT - C_m

SYMBOL	d	y	c	FROUDE NO.	CAV. NO.
Ø		7.5		5.6280	261
▲		1.00		4.8924	280
□		1.25		4.4025	298

Note

L. DAW
INDEX

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三

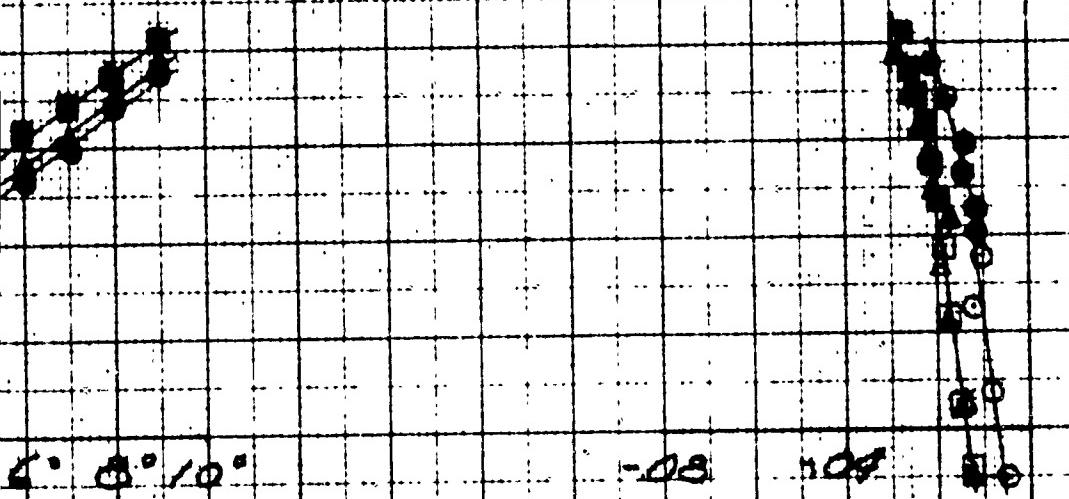
Dope Cages - C

~~HANGER ON
DEGREES~~

PAGE 1 IN 63

W.I.F. NO. 51 BUSINESSES FOIL No. 12
M.A.C. = 182 FT. AREA = 8,000"
VEL = 60 KTS.

DARKENED SYMBOLS
INDICATE VENTED FLOW.



5° 0° 10°

-08 108 110

ATTACH
5-5

DETACHING MOMENT
COEFF - C_M

SYMBOL	Δ/c	FROUDE NO.	CAR. NO.
-e	.73	5.63	208
-a	1.00	4.89	228
-d	1.25	4.40	247

NOTE:

1. DRAG
IND.

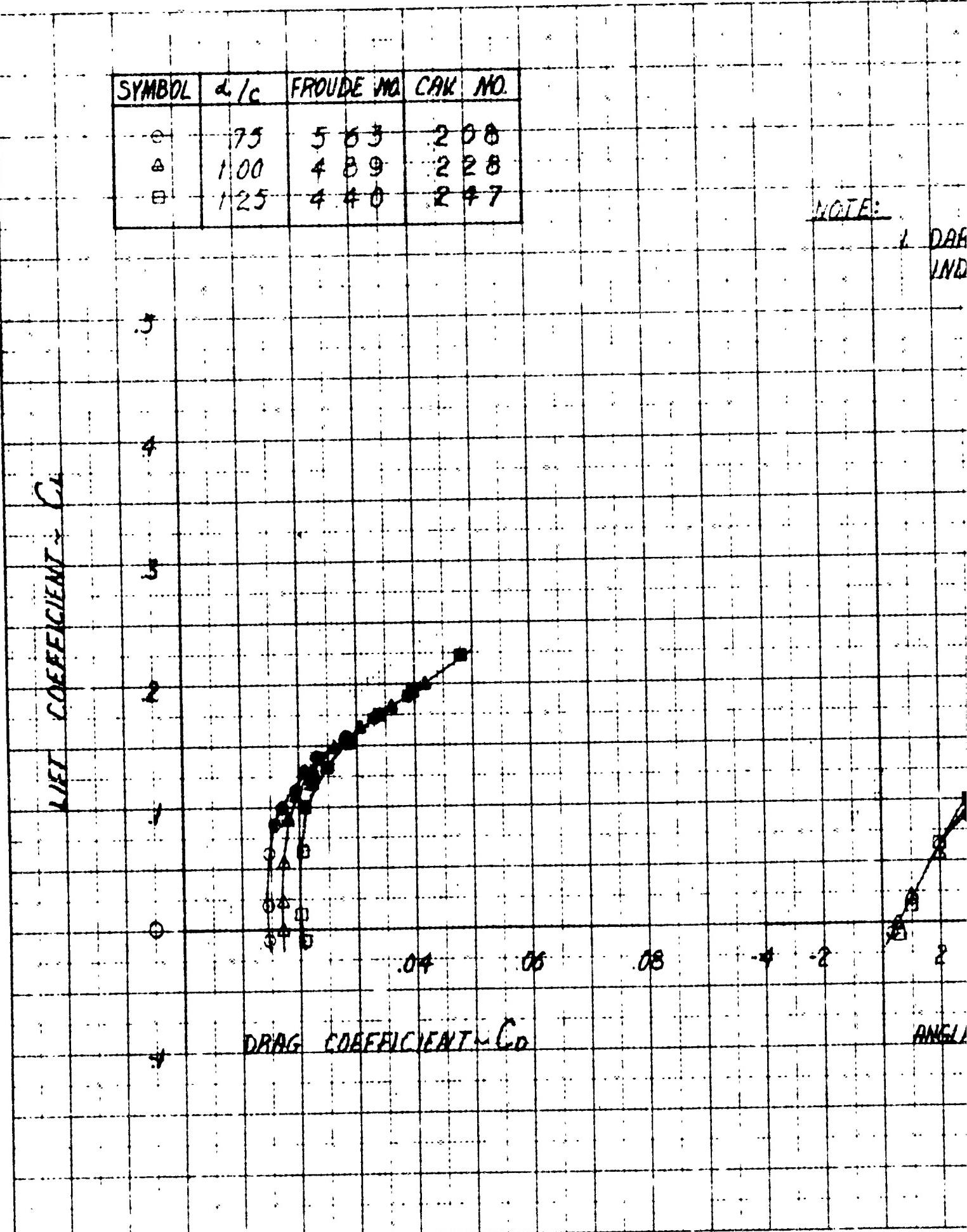
JET COEFFICIENT - C_j

K-E APPROXIMATE FORMULA

12/10

DRAG COEFFICIENT - C_d

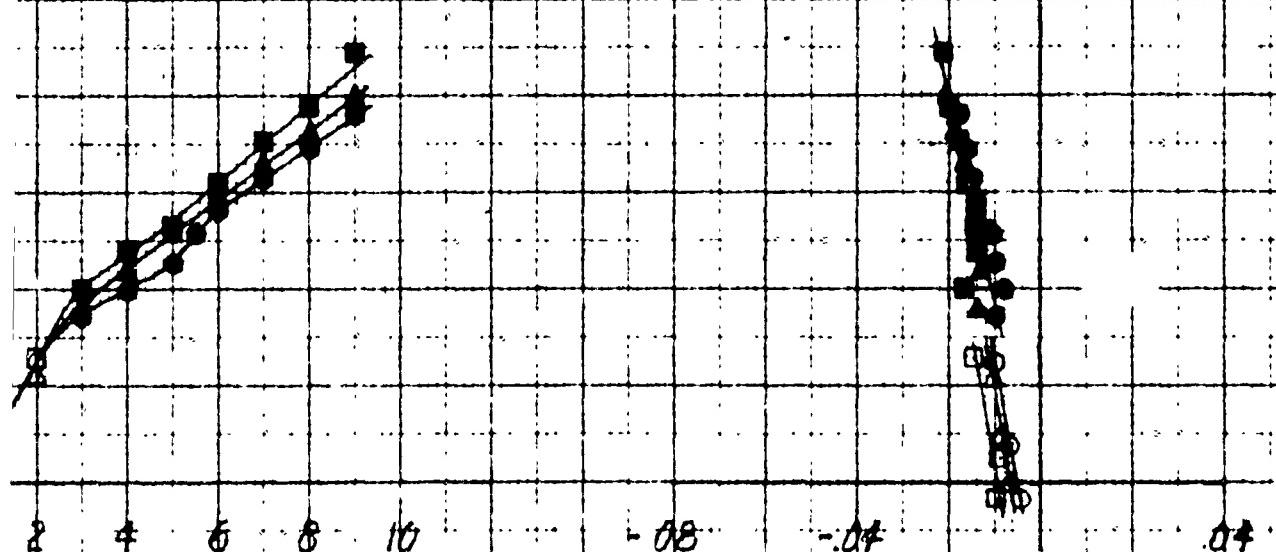
ANGLE



PAGE N^o 64

WHIRLING TANK TEST NO. 51
BU SHIPS FOIL NO. 12
 $MAC = 182 \text{ EC}$; $S = 8.06 \text{ in}^2$
 $V = 70 \text{ KTS.}$

DARKENED POINTS
INDICATE VENTED FLOW.



ANGLE OF ATTACK - α - DEG

PITCHING MOMENT
COEFFICIENT - C_m

SYMBOL	d/c	FROUDE NO.	CAV. NO.
0	.75	5.6200	.172
△	1.00	4.8924	.192
□	1.25	4.2025	.211

NOTE
1.0
1.0

5

4

3

2

1

0

-1

H.E. 50mm 1000 2100

Set Close



0.02 0.04 0.06 0.08

2° 4°

Drag COEFF = C_D

ANGLE OF
DEGR

PAGE IV.65

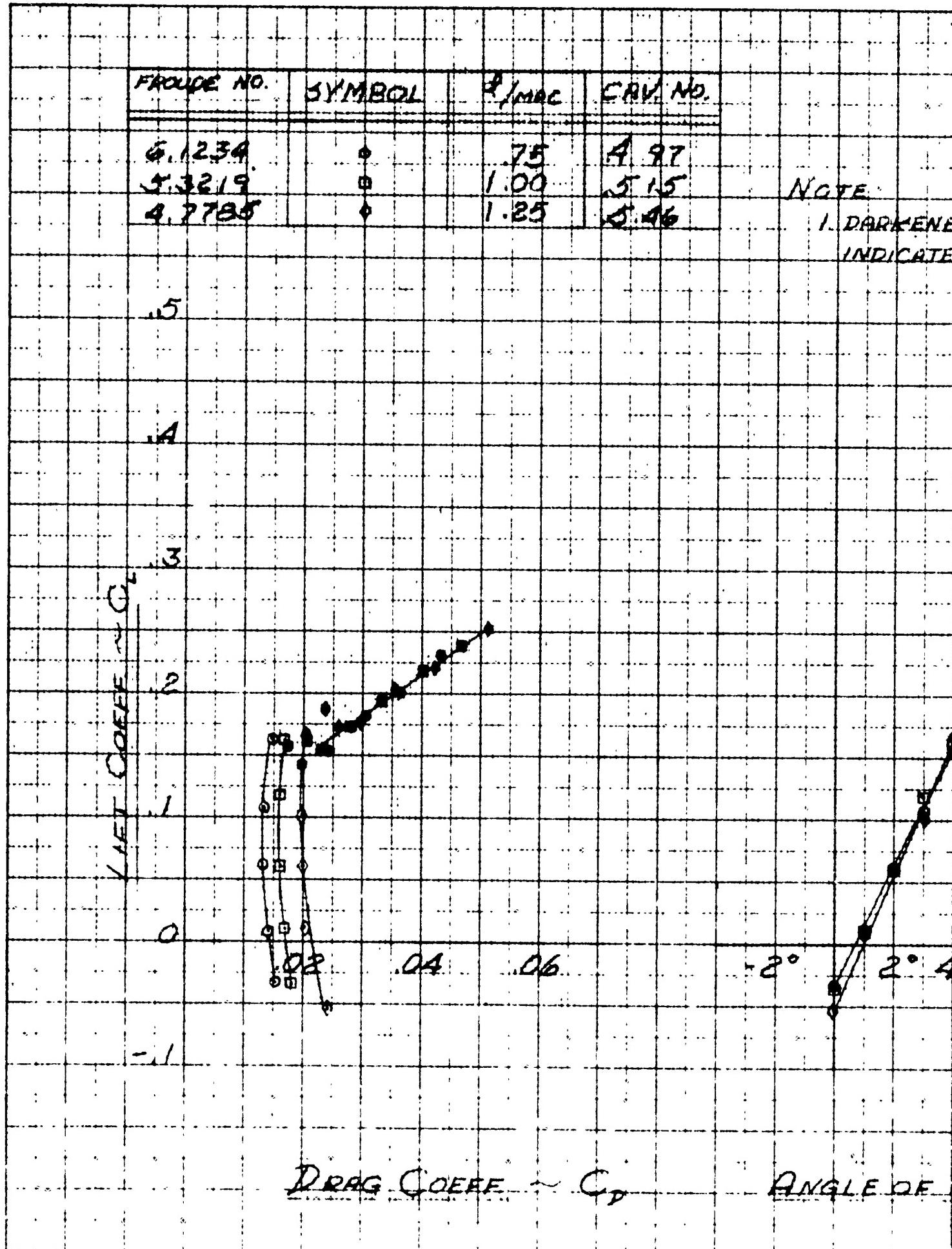
WT T No. 51 BUSHIPS FOIL NO. 12
MAC = 102 FT. AREA F 0.0001
VBL = 80 KTS

DARKENED SYMBOLS
INDICATE VENTED FLOW.

• 6° 8° 10° .03 .04 0

OF ATTACK
GREES

PITCHING MOMENT
COEFF - C_M_A



PAGE IV.66

WHIRLING TANK TEST NO. 41

BUSHING FOIL NO. 13

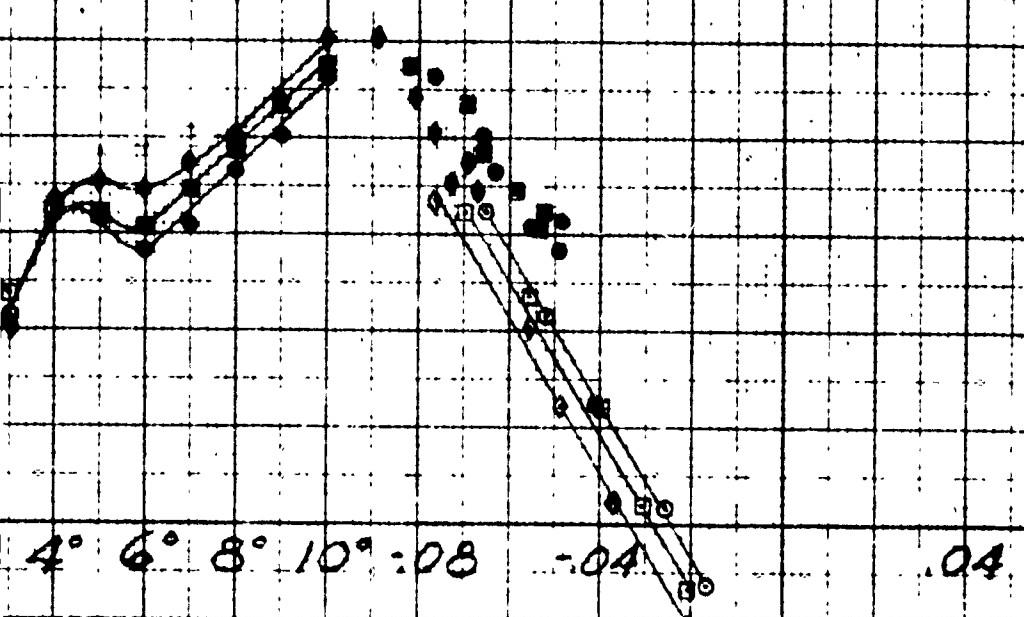
M.A.C. = 152 FT. AREA = 8.32 IN²

V = 40 KTS

ENED SYMBOLS

RE VENTED FLOW

K.E. 100% 100%

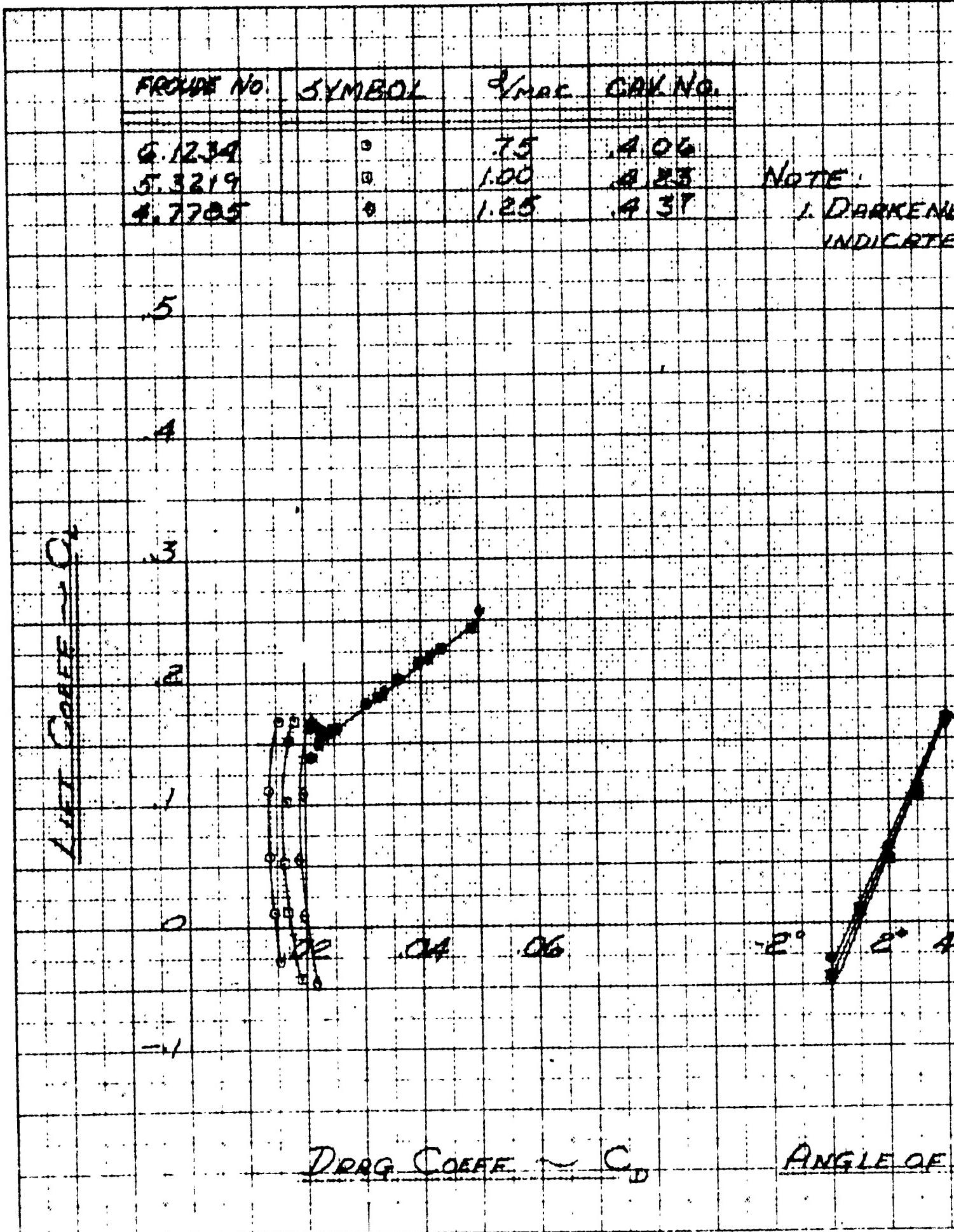


4° 6° 8° 10° 0° -0.04 0.04

ATTACK ~ 4 ~ DEG.

PITCHING MOMENT COEFF.

C_M about 9% of M_{∞}



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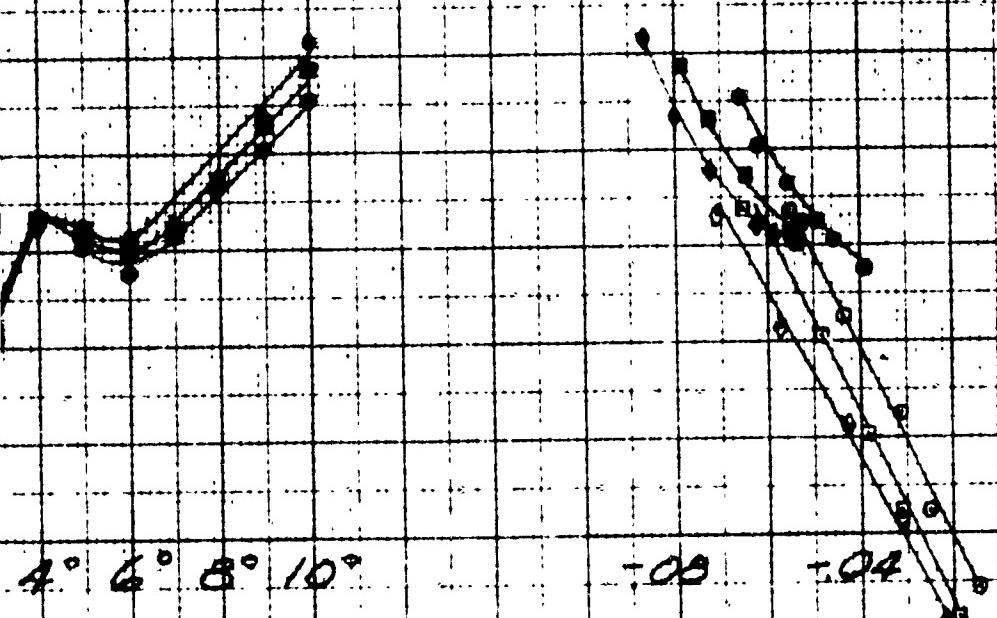
WHIRLING TANK TEST NO. A1

BUSHNELL FOIL NO. 13

MAC. = 152 FT. AREA = 8 SQ. IN.

V = 25 KTS

UNED SYMBOLS
RE DENTED FLOW



4° 6° 8° 10°

+00 +02

ANGLE OF ATTACK = α = 7 DEG.

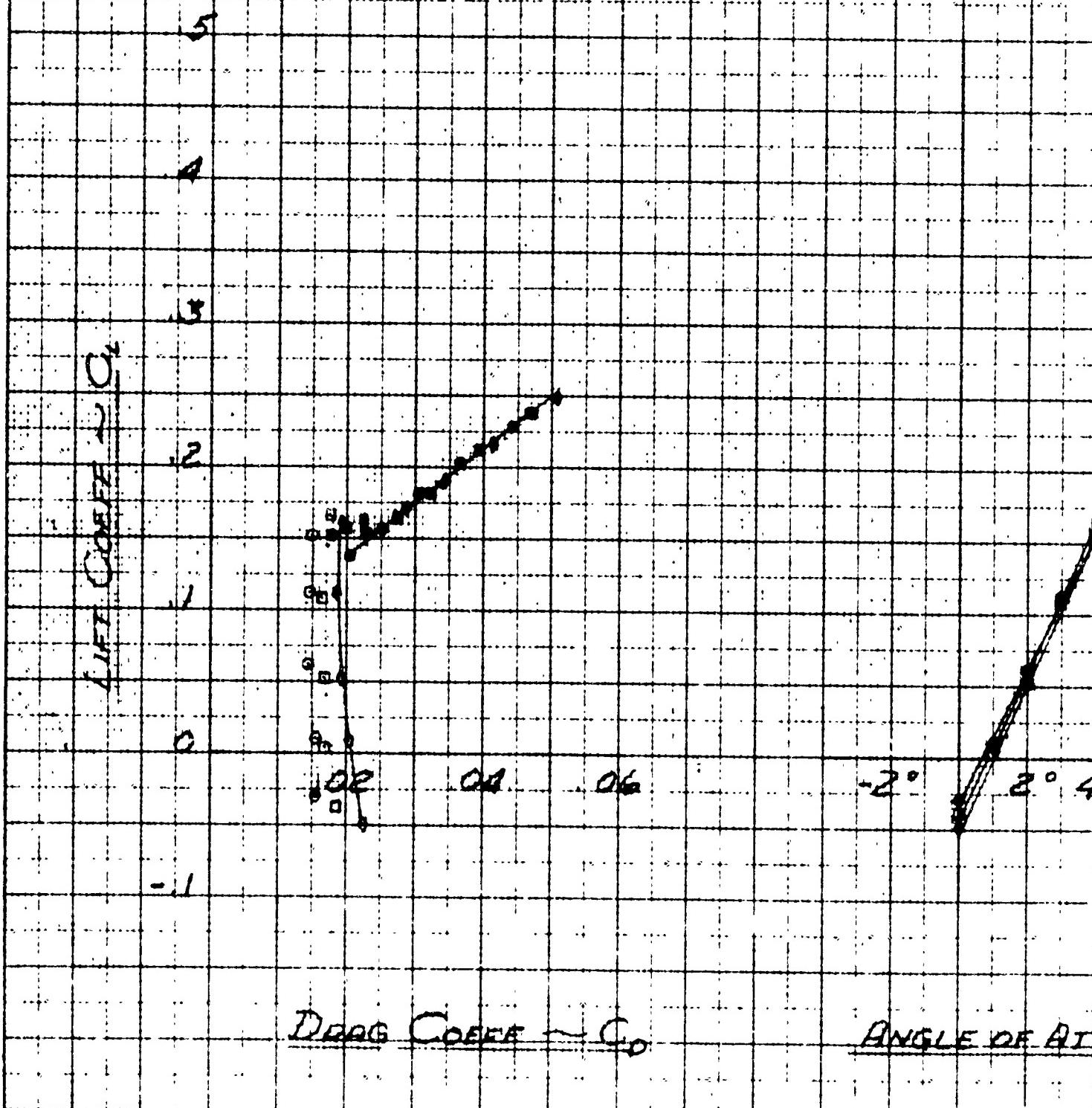
PITCHING MOM. COEFF.

$C_{M_{pitch}}$ = 1.0 at 7 deg

SYMBOL PLATE FROUDE NO GAV NO

	75	61230	3.01
o	1.00	53219	3.51
o	1.25	47780	3.74

NOTE 1
1. DARKER
INDICAT



PAGE IV.6B

WHIRLING TANK TEST NO 41

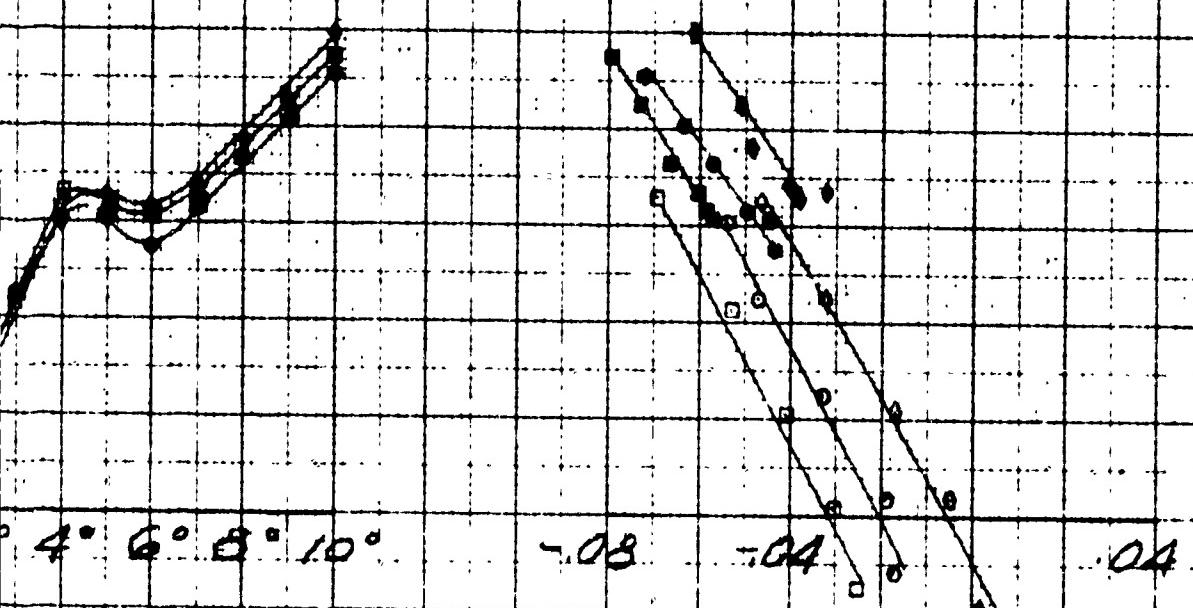
BUSHIPS FOIL NO 13

M.A.C. = 152 FT AREA = 810

V = 50 KTS

ENED SYMBOLS
ATE VENTED FLOW

K-E 8
1968



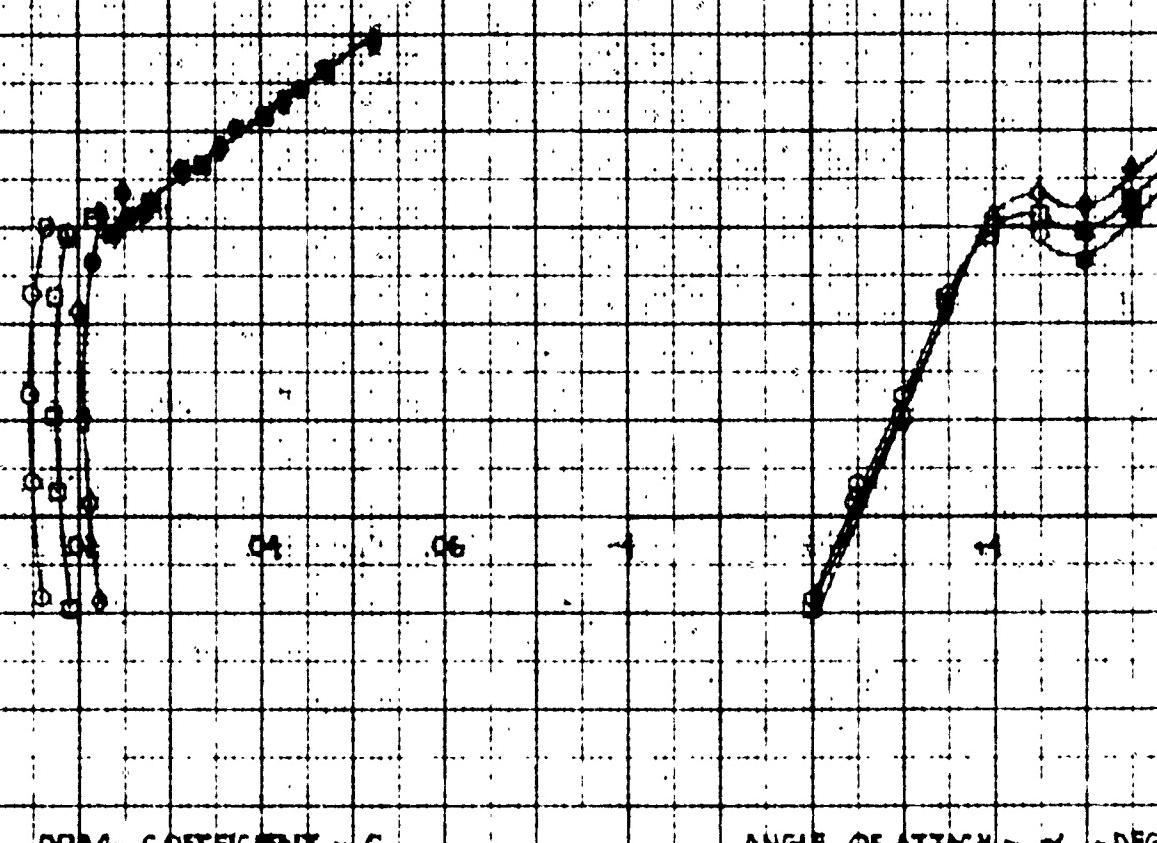
ATTACK = α - DEG DITCHING MOMENT COEFF - C_M
REPORT 12 OF MG C.

WHIRLING TANK TEST
BU SHIPS FOIL # 13
M.A.C. : .152 FT. S.
VELOCITY : 60 KTS

SYMBOL	D/C	FROUDE NO.	CAV NO.
○	.75	6.12	.255
□	1.00	5.32	.270
◆	1.05	4.78	.284

ME: 10000 - 10000

LIFT COEFFICIENT - CL



DRAG COEFFICIENT - C_D

ANGLE OF ATTACK - α - DEG

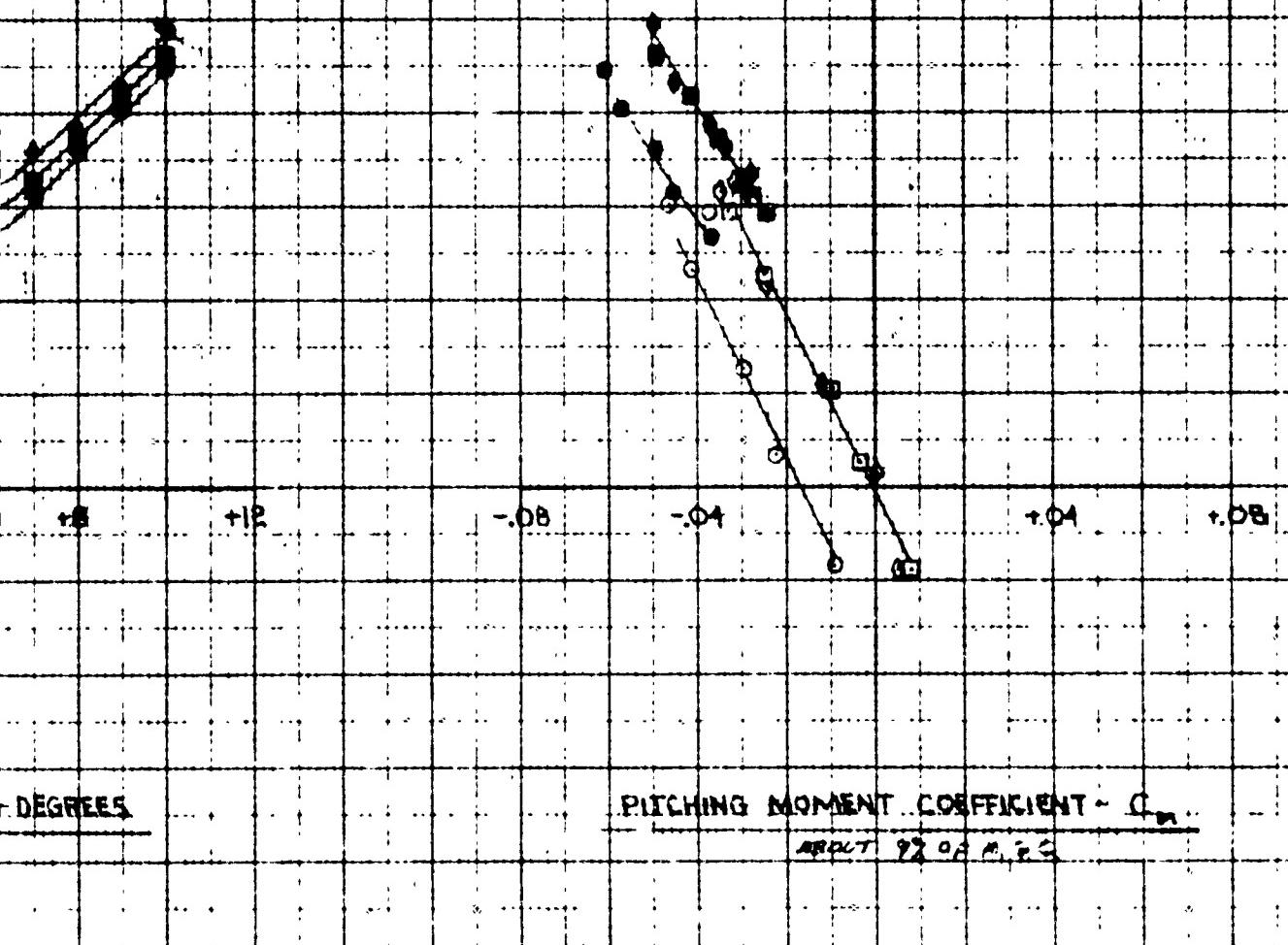
T NO 41

13

.5 = 8.09 IN²

B

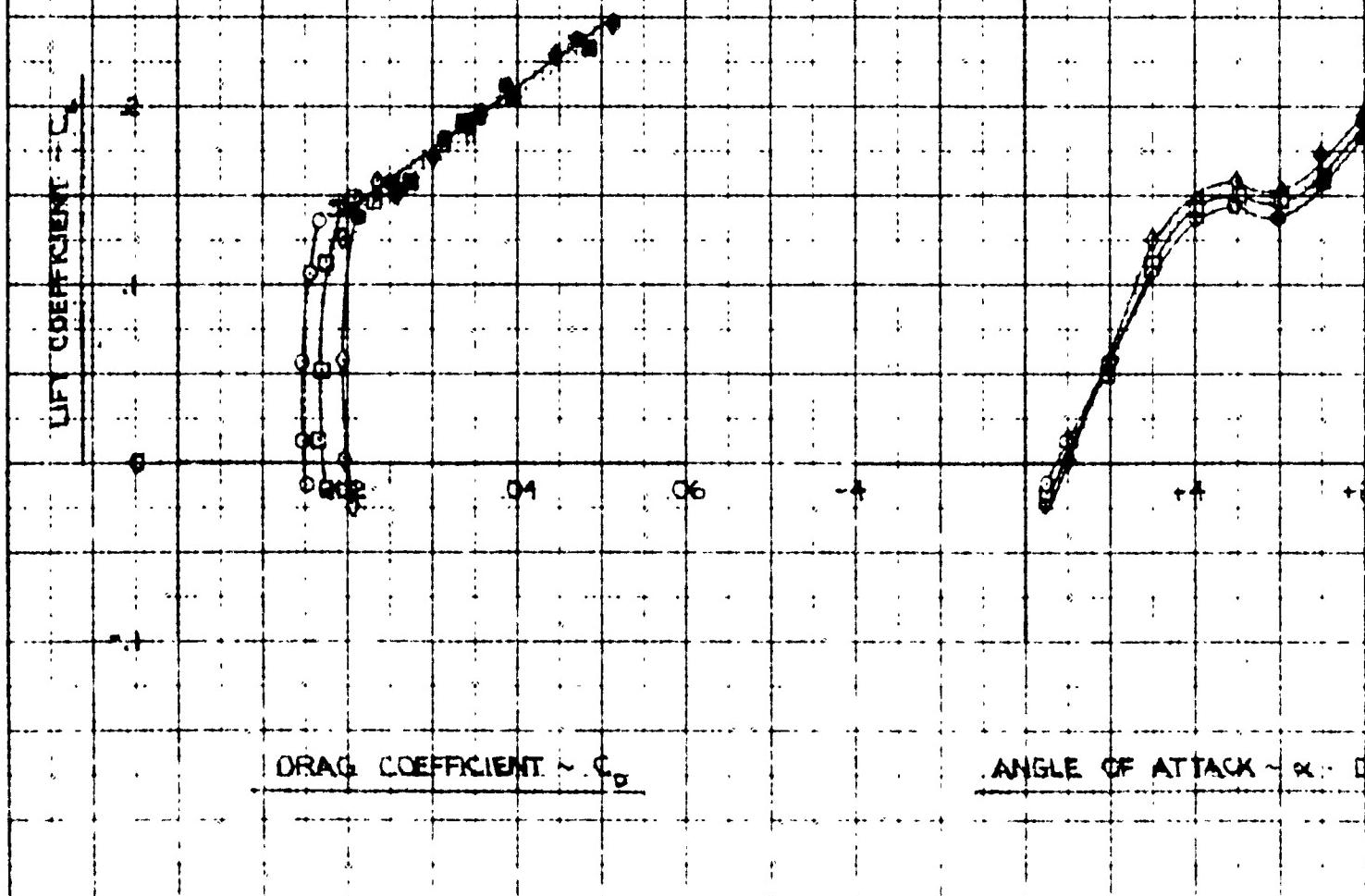
NOTE: DARKENED POINTS INDICATE
VENTED FLOW.



WHIRLING TANK TEST. N
BU SHIPS FOIL # 13

MAX. LIFT FT. = 5.800
VELOCITY = 70 KTS

SYMBOL	d/c	FRICTION	CAV.
		NO.	NO.
○	.75	5.12	.159
□	1.00	5.32	.219
◆	1.25	4.78	.252



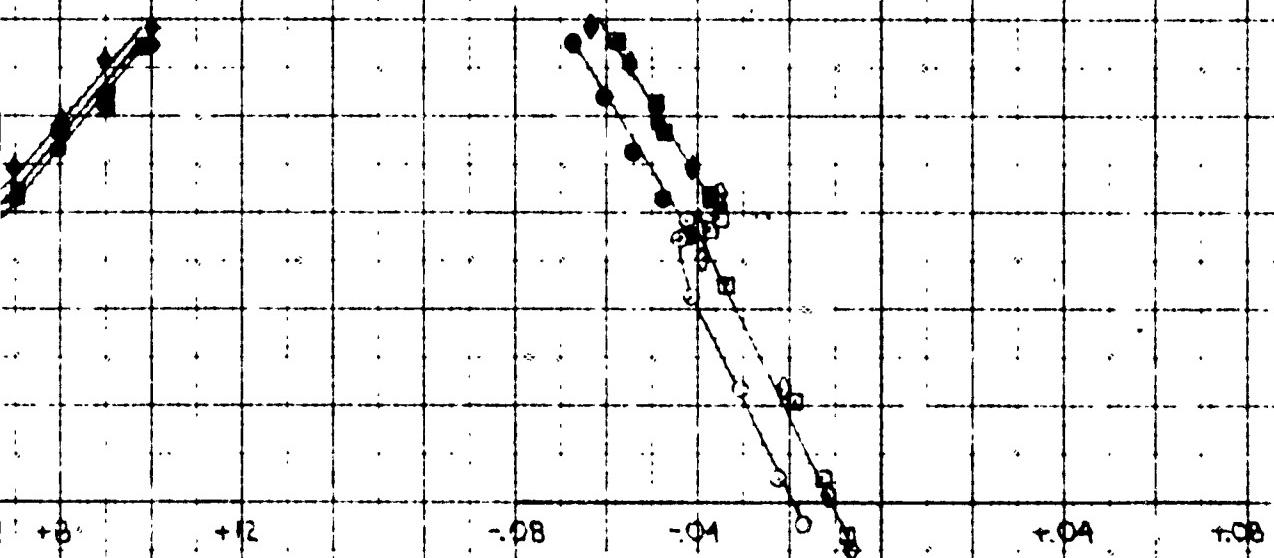
T. NO. 41

PAGE 1470

300 N⁴
S

NOTE: DARKENED POINTS INDICATE VENTED FLOW.

100 200 300



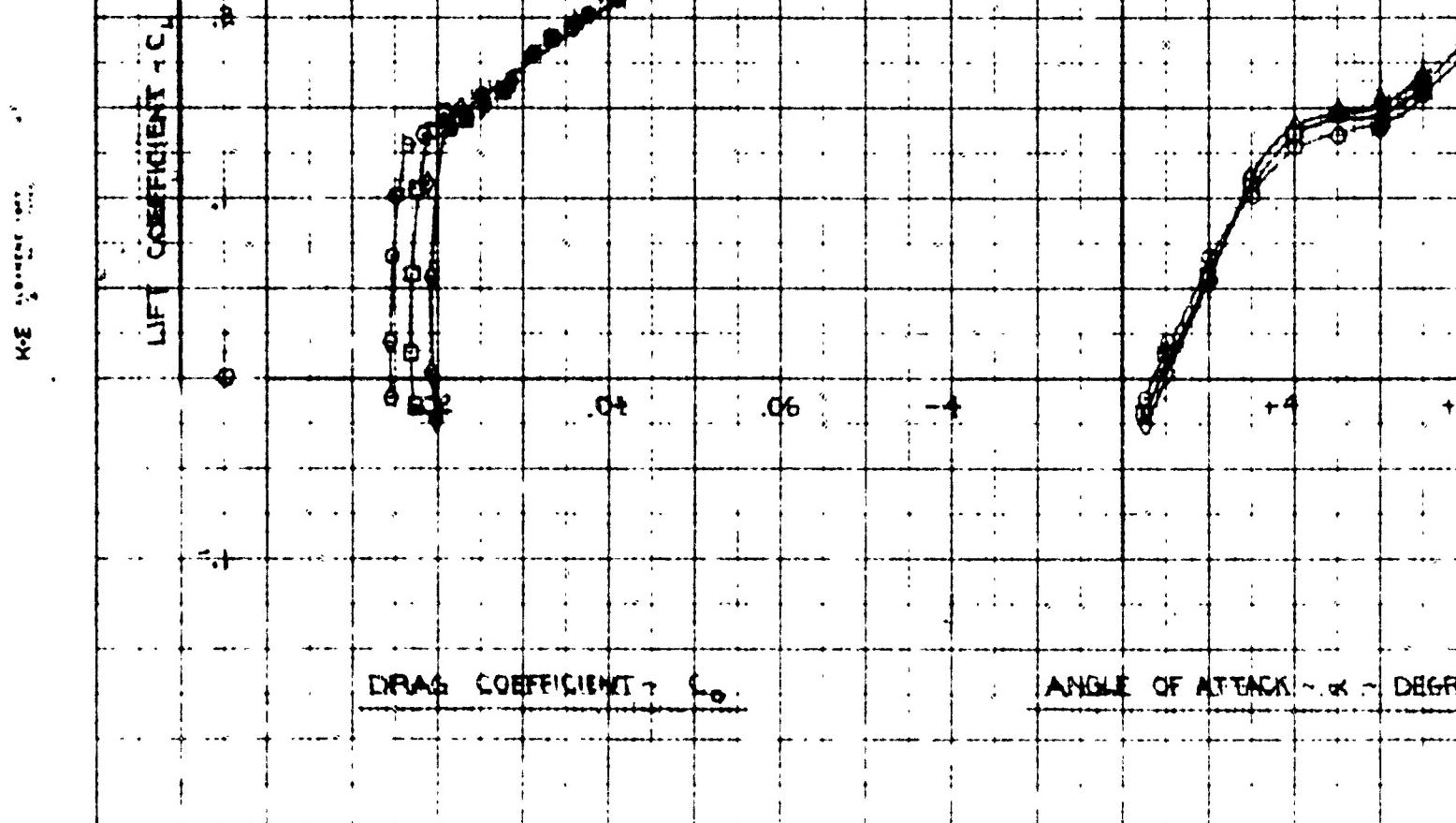
DEGREES

PITCHING MOMENT COEFFICIENT ~ C_M

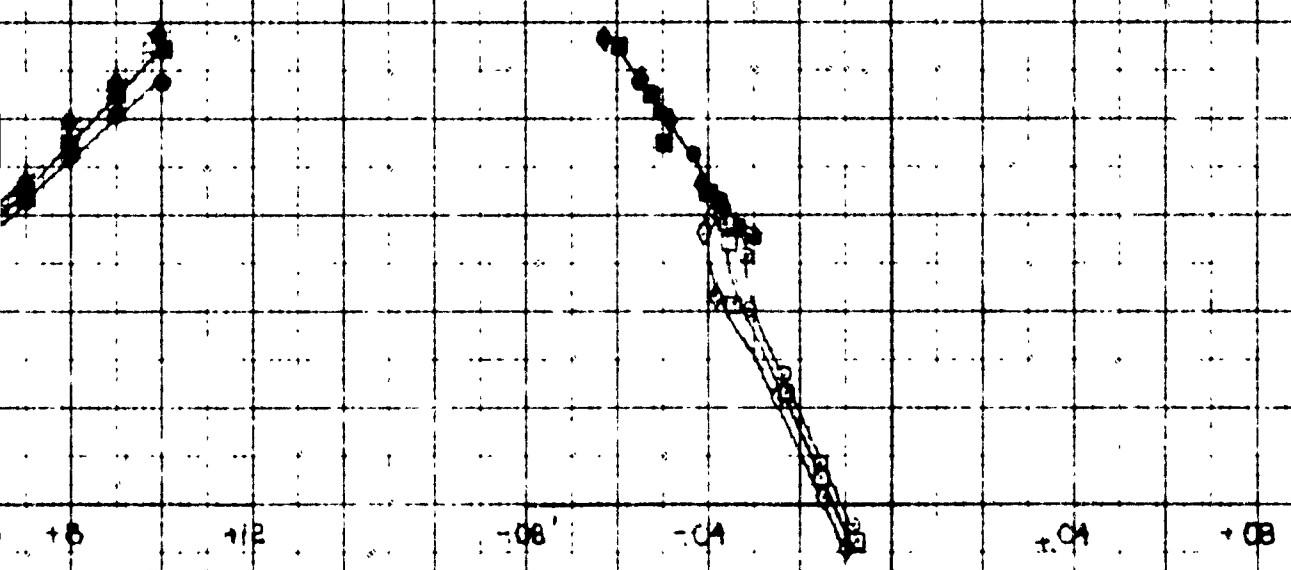
-0.08 -0.06 -0.04 -0.02 0.00 0.02 0.04 0.06

WHIRLING TANK TEST NO. 41
BY SHIPS FOIL #13
M.E.C. = 152 - 3' BODIN²
VELOCITY = 80 KTS.

SYMBOL	d/c	FROUDE NO	CAV. NO
◆	.75	6.78	.174
□	1.00	5.32	.195
○	1.25	4.98	.210

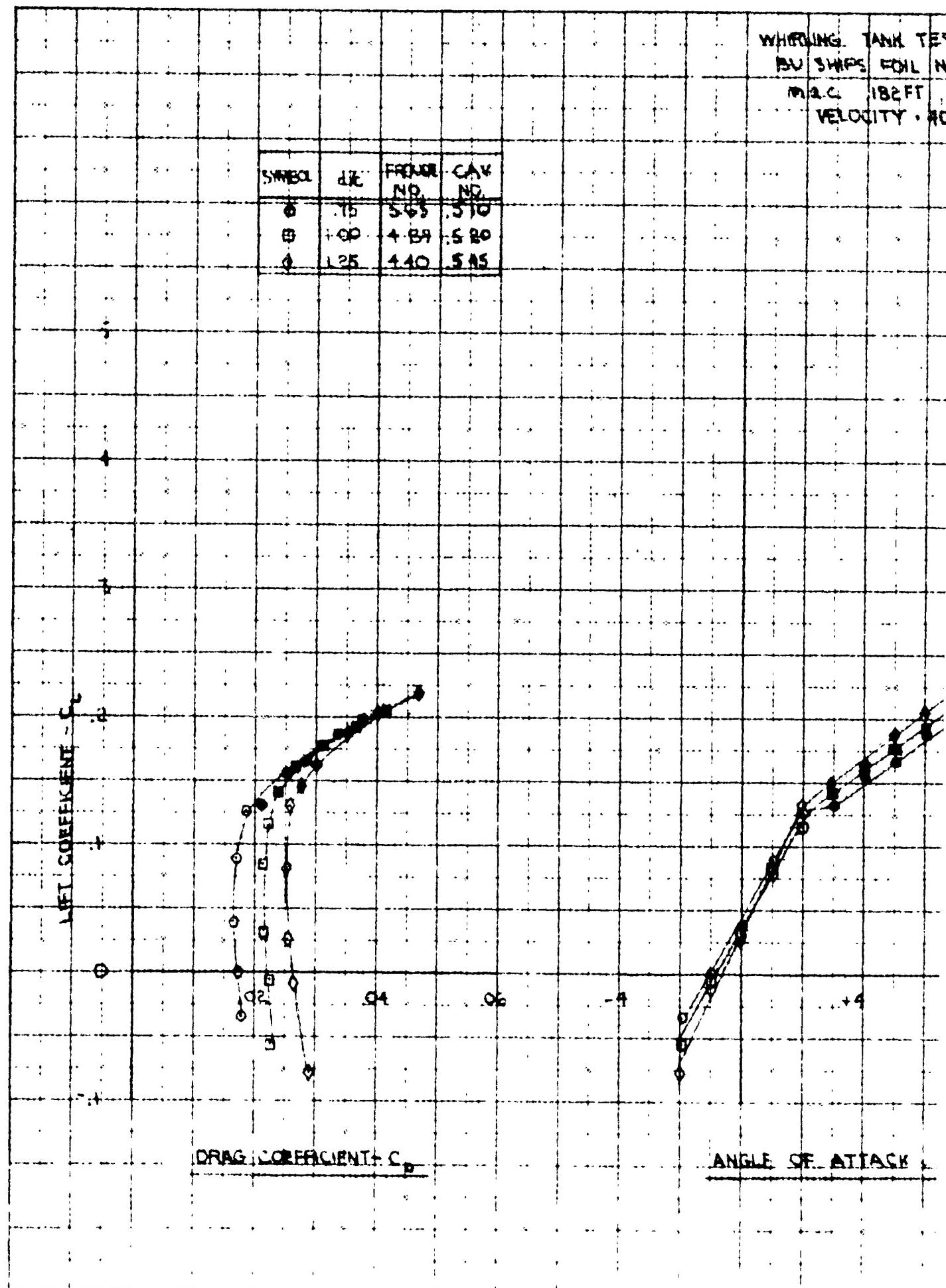


NOTE DARKENED POINTS INDICATE
VENTED FLOW



WHIRLING TANK TEST
BU SHIPS FOIL NO
M.A.C. 182 FT
VELOCITY .40

SYMBOL	d/c	FRONDE CAV	
		ND	ND
•	.75	5.65	.510
□	+00	4.84	.520
○	1.25	4.40	5.15

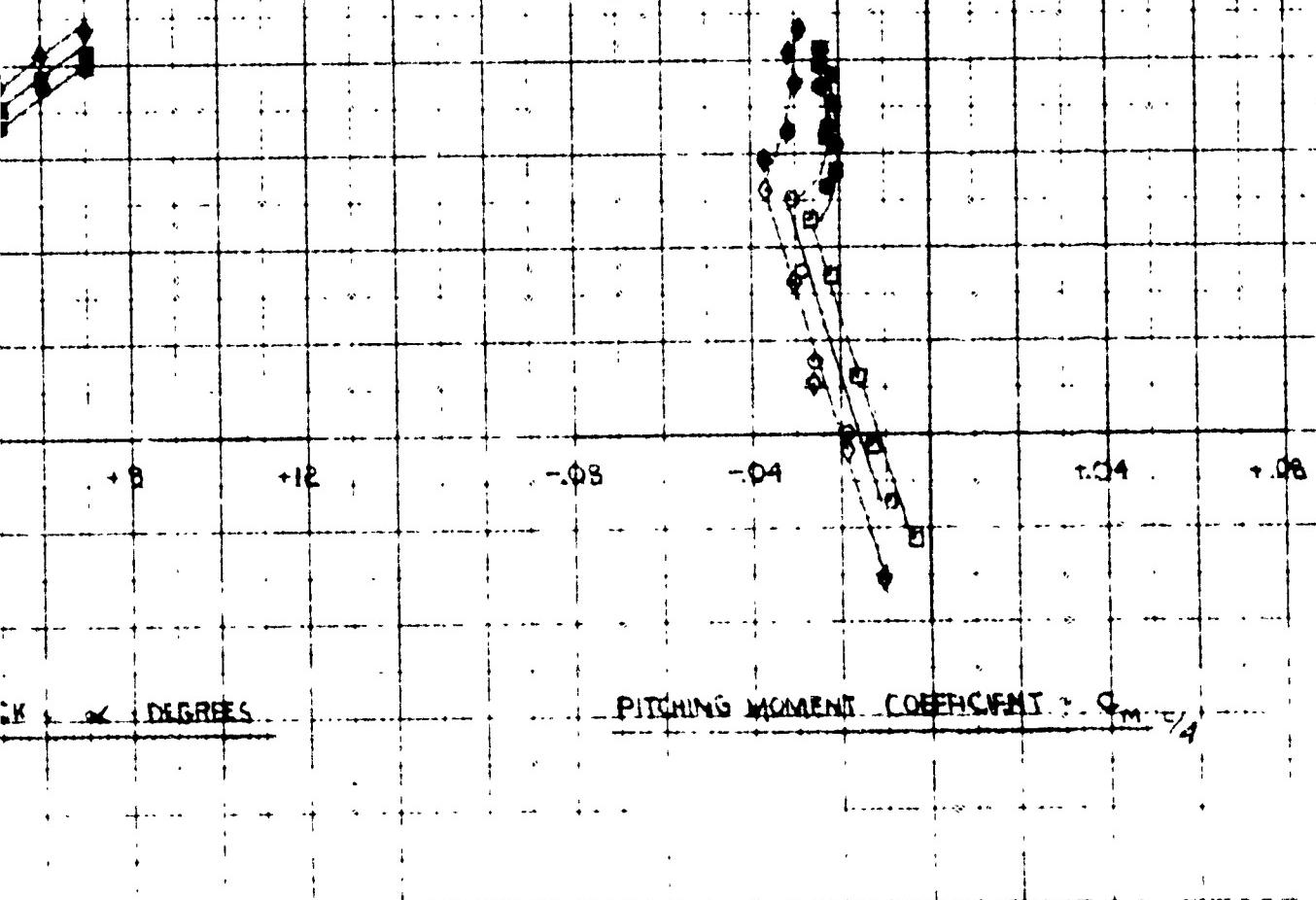


TEST NO 43
L NO 14
FT. 9.800 IN.
• 80 KTS

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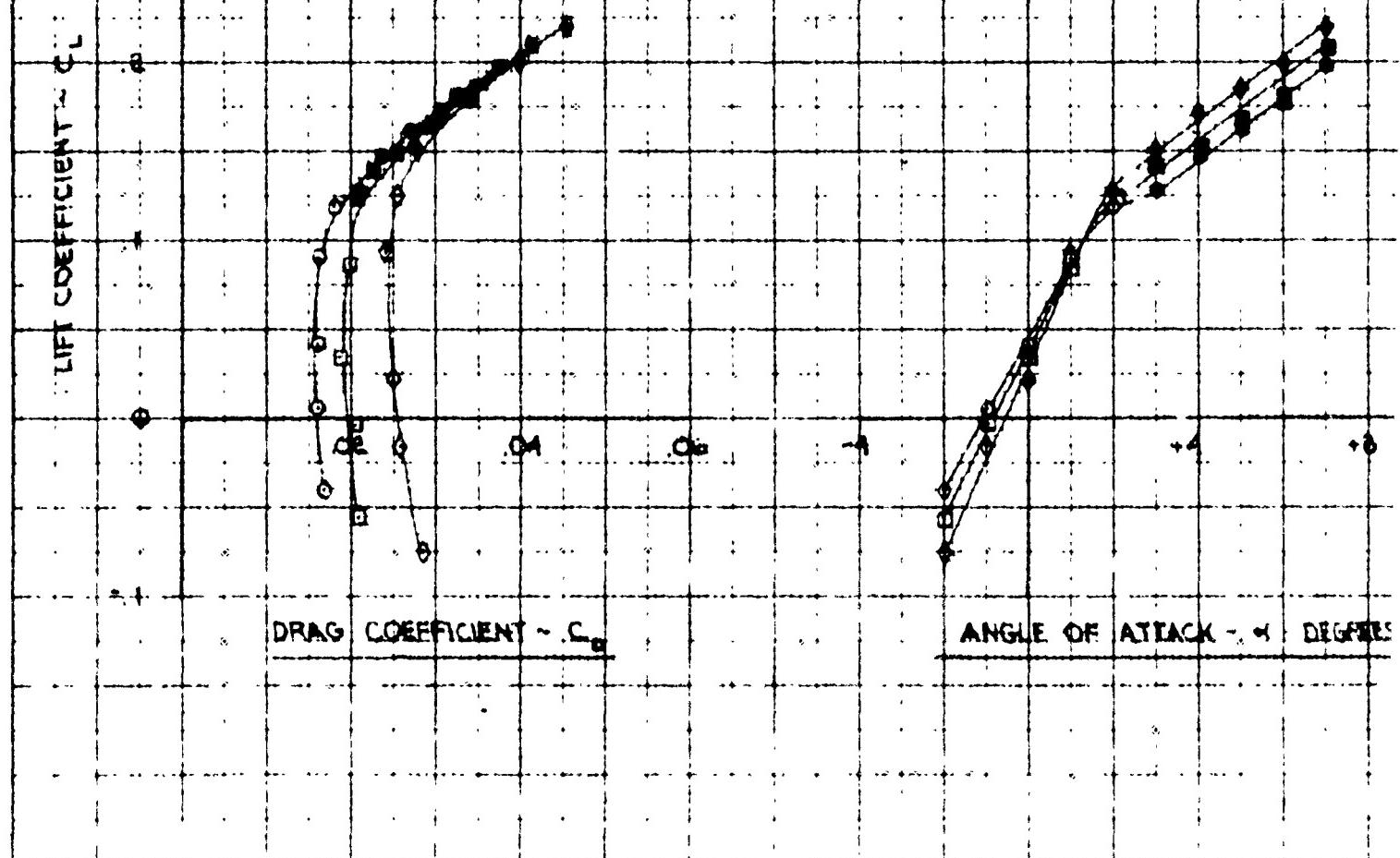
NOTE DARKENED POINTS INDICATE VENTED FLOW

NO. 301



WHIRLING TANK TEST NO 47
BU SHIPS FOIL NO 14
TRAC. T. BEAPT, 5-15-2000
VELOCITY - 45 KTS

SYMBOL	c_d	FRICTION NO	CAV NO
●	.15	5.65	3.10
○	1.00	4.87	4.34
▲	1.25	4.40	4.59



PAGE IV.73

NOTE: DARKENED POINTS INDICATE VENTED FLOW.

-0.02 -0.08 -0.04 +0.04 +0.08

PITCHING MOMENT COEFFICIENT - $C_{M,1/4}$

WHIRLING TANK TEST 43

BU SHIPS FULL * 14

IN G.C. 182 ft. S. BUDING

VELOCITY: 50 KTS

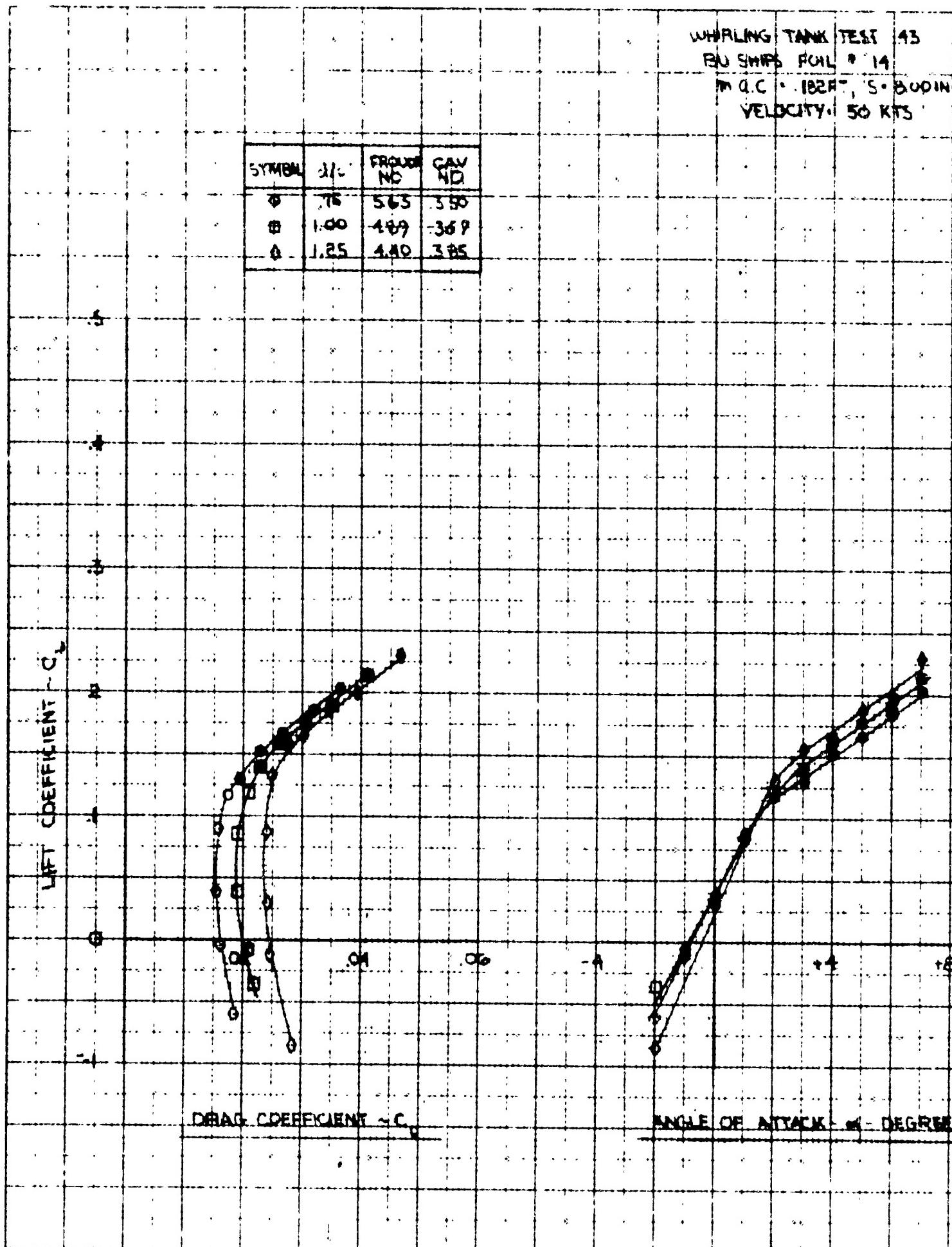
SYMBOL	α/α	FRGUE NO	GAV NO
○	.75	563	350
□	1.00	489	-369
△	1.25	440	385

K-E STABILIZER

LIFT COEFFICIENT - C_L

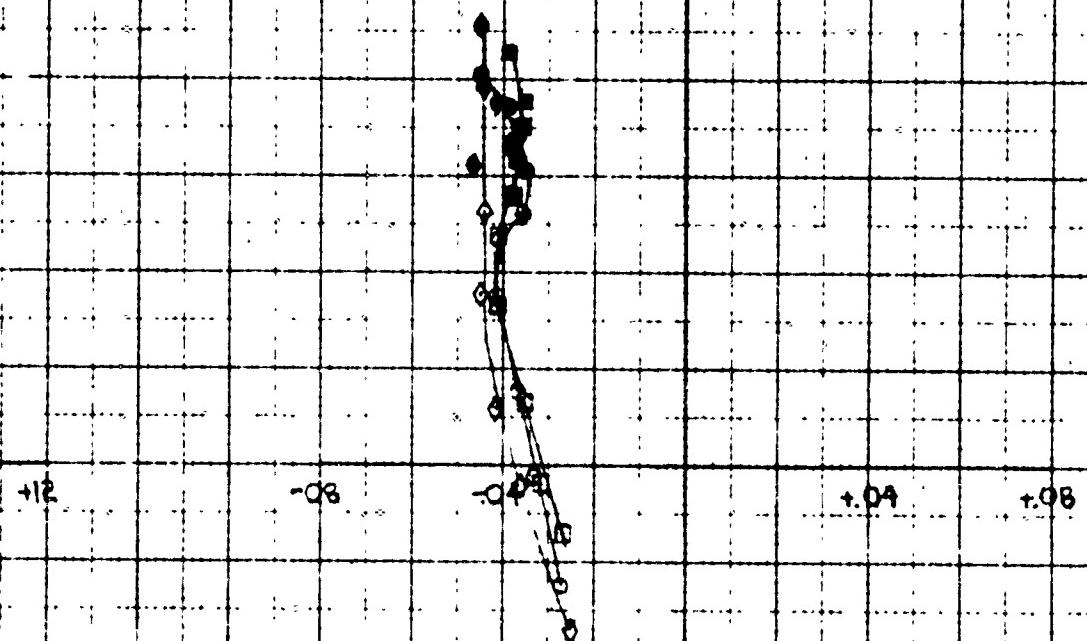
DRAG COEFFICIENT - C_D

ANGLE OF ATTACK - α - DEGREES

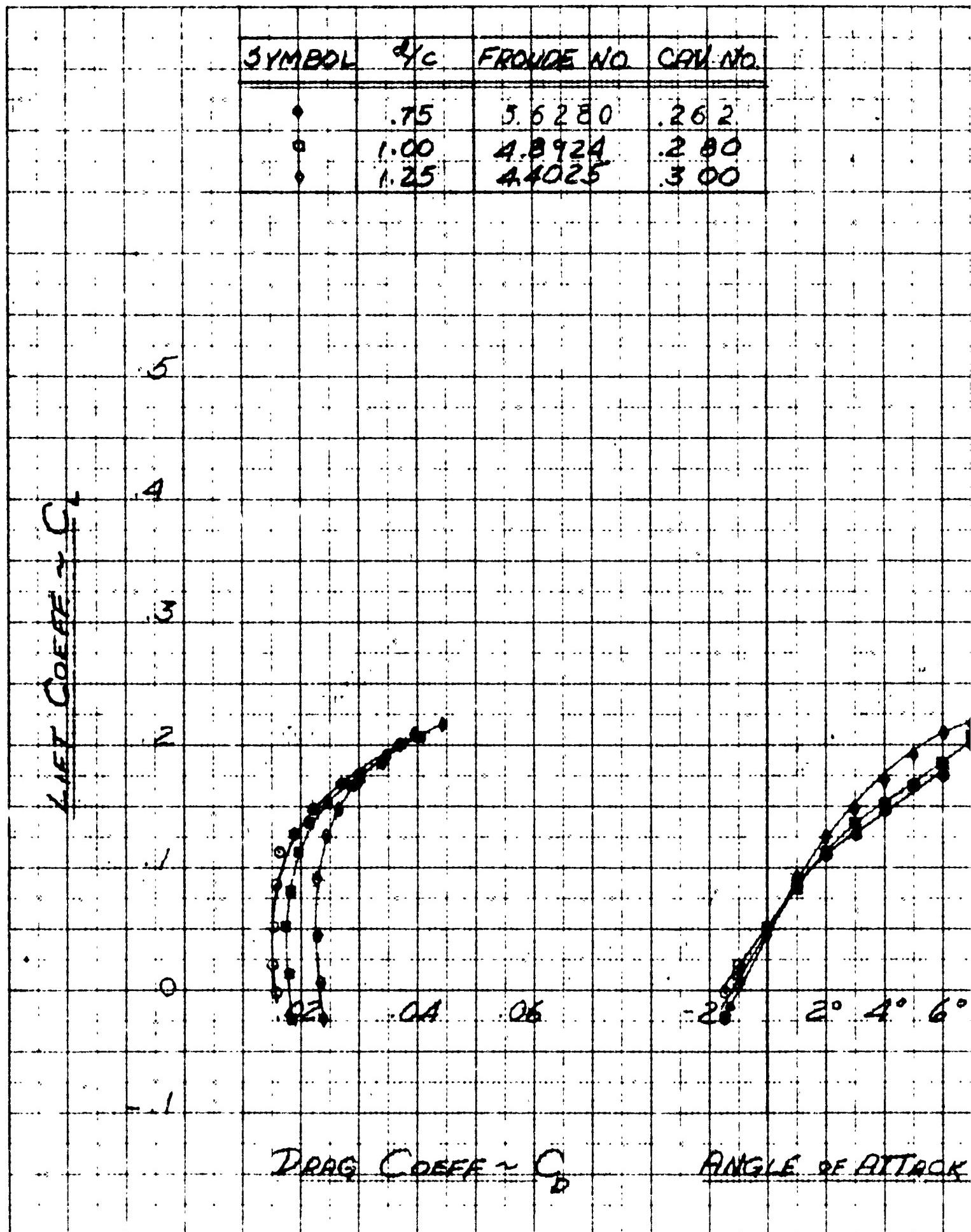


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NOTE: DATA POINTS INDICATE VENTED FLAP.



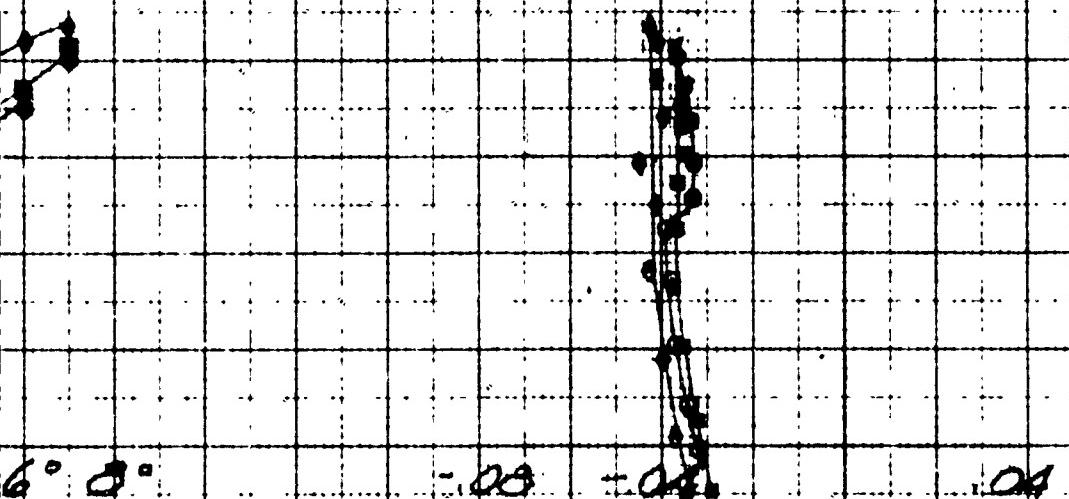
PITCHING MOMENT COEFFICIENT ~ C_m



PAGE IV, 75

WELLING TANK TEST 43-BUSHIPS NO. 14
MAC = .182 FT AREA = 8 SQ. IN.
 $V = 60 \text{ RPS}$

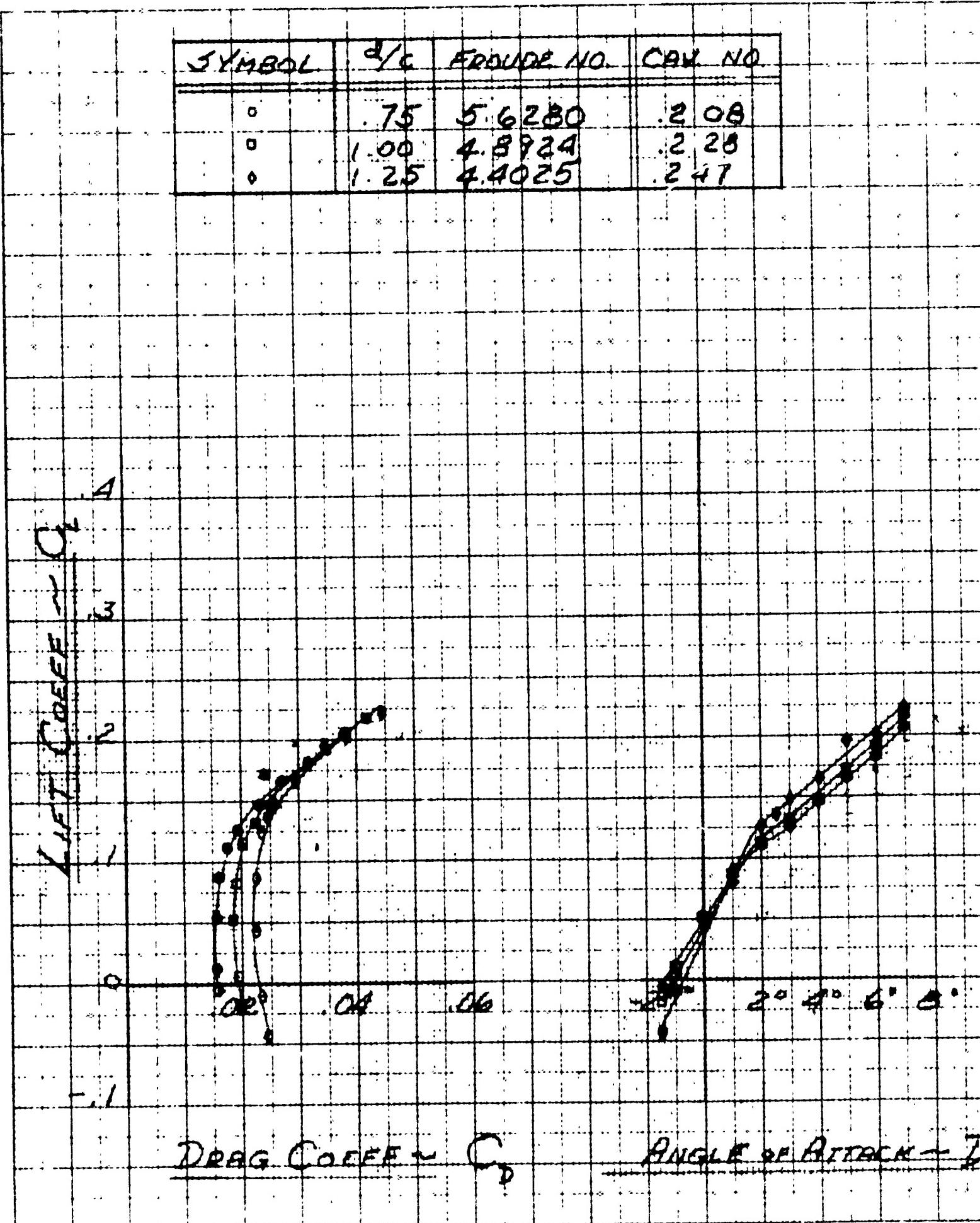
NOTE CARRIAGED POINTS INDICATE VENTED FLOW



$6^\circ 0'$ -03 $+04$ -04

CK - DEG

DITCHING MOMENT COEFF + C



PAGE IV.16

WHIRLING TANK TEST Q3 - BUSH IRS NO 10

M.A.C. = .182 FT. - AREA = 2 SQ. IN.

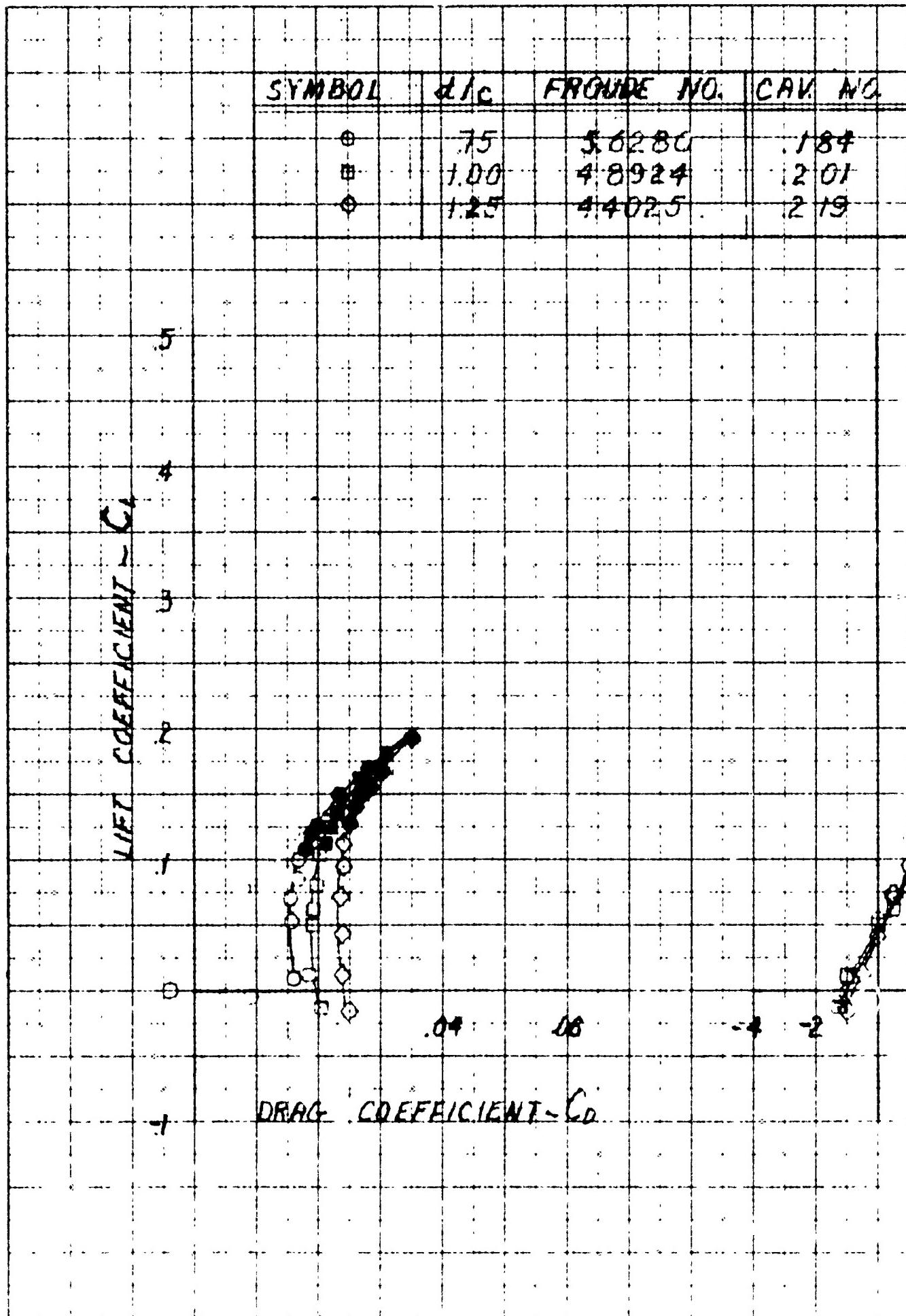
V = 70 KTS

NOTE: DARKENED POINTS INDICATE VENTED FLOW

-08 -10 08 08

- DEG

PITCHING MOMENT COEFF - C_m



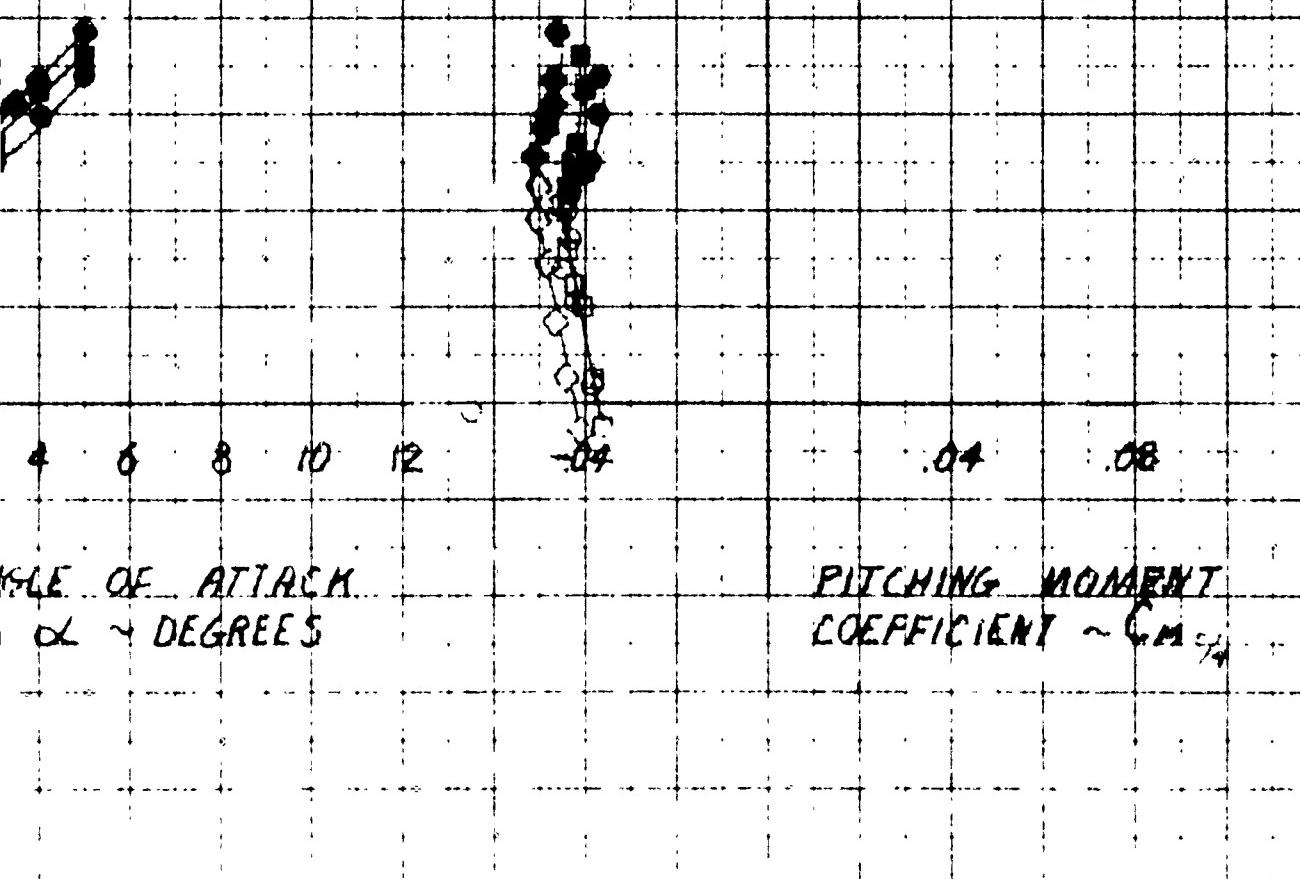
PAGE IV 77

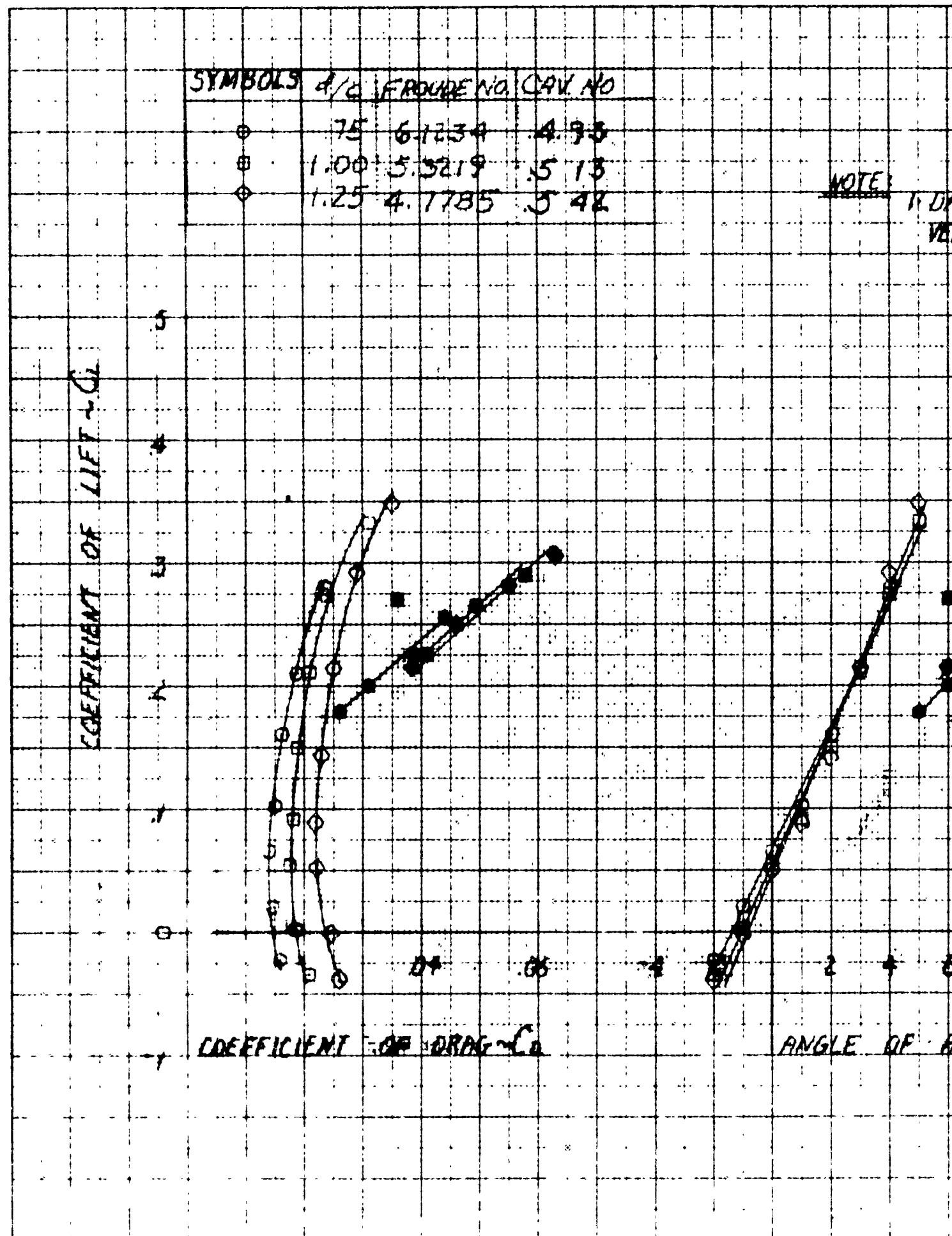
WHIRLING TANK TEST NO. 43
FOIL NO. 14 MAC = 0.182 FT
AREA = 8.00 SQ IN.

V = 80 KTS.

TE 1

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.



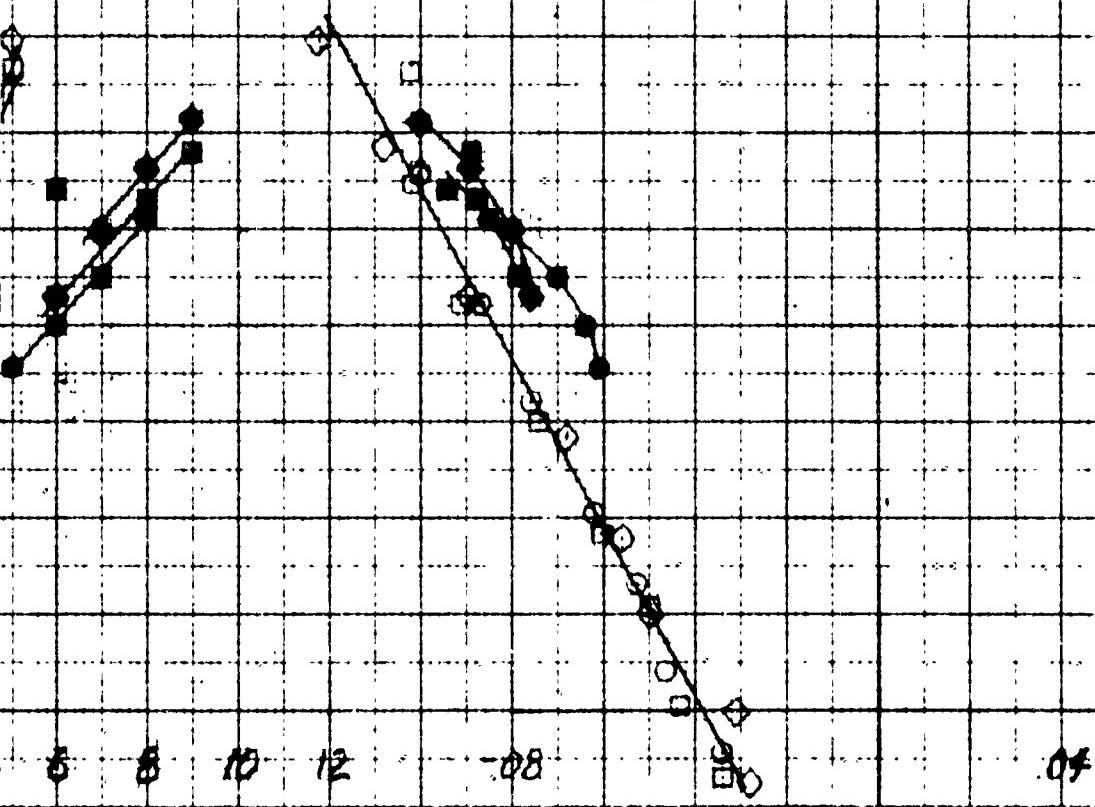


PAGE 1 OF 18

WHIRLING TANK TEST NO 44

BUSHES FULL AND 15°
M.A.C. = 152 FT AGL & 80° IN
 $V = 40 \text{ KTS}$

UNMARKED SYMBOLS INDICATE
VENTED FLOW.



SYMBOLS d/c FRACTION CAV. NO.

0.75	8.12	4.06
1.00	5.32	4.22
1.25	4.78	4.37

NOTE:

1. DAA
VEN

COEFFICIENT OF LIFT - C_L

5

4

3

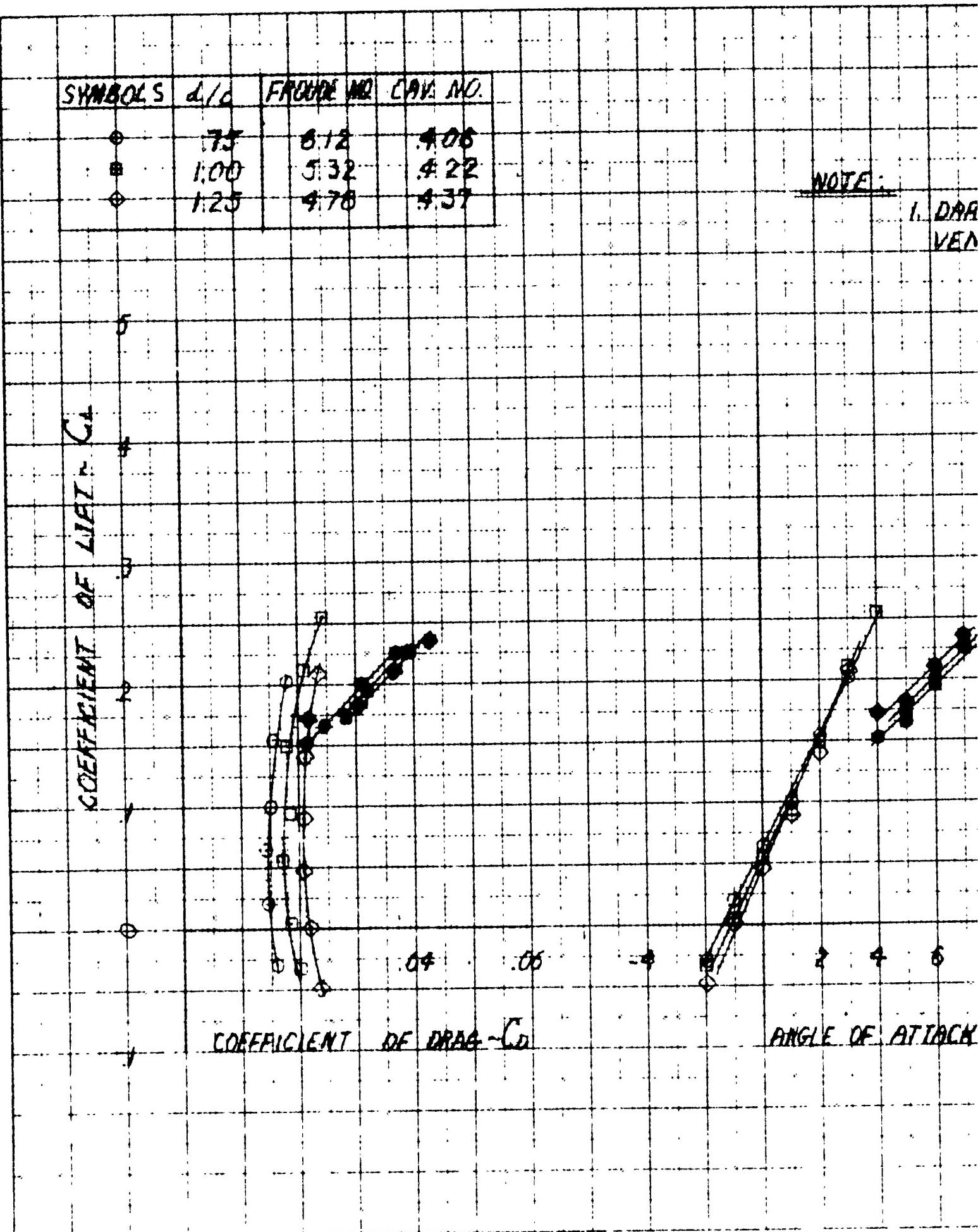
2

1

0

COEFFICIENT OF DRAG - C_D

ANGLE OF ATTACK



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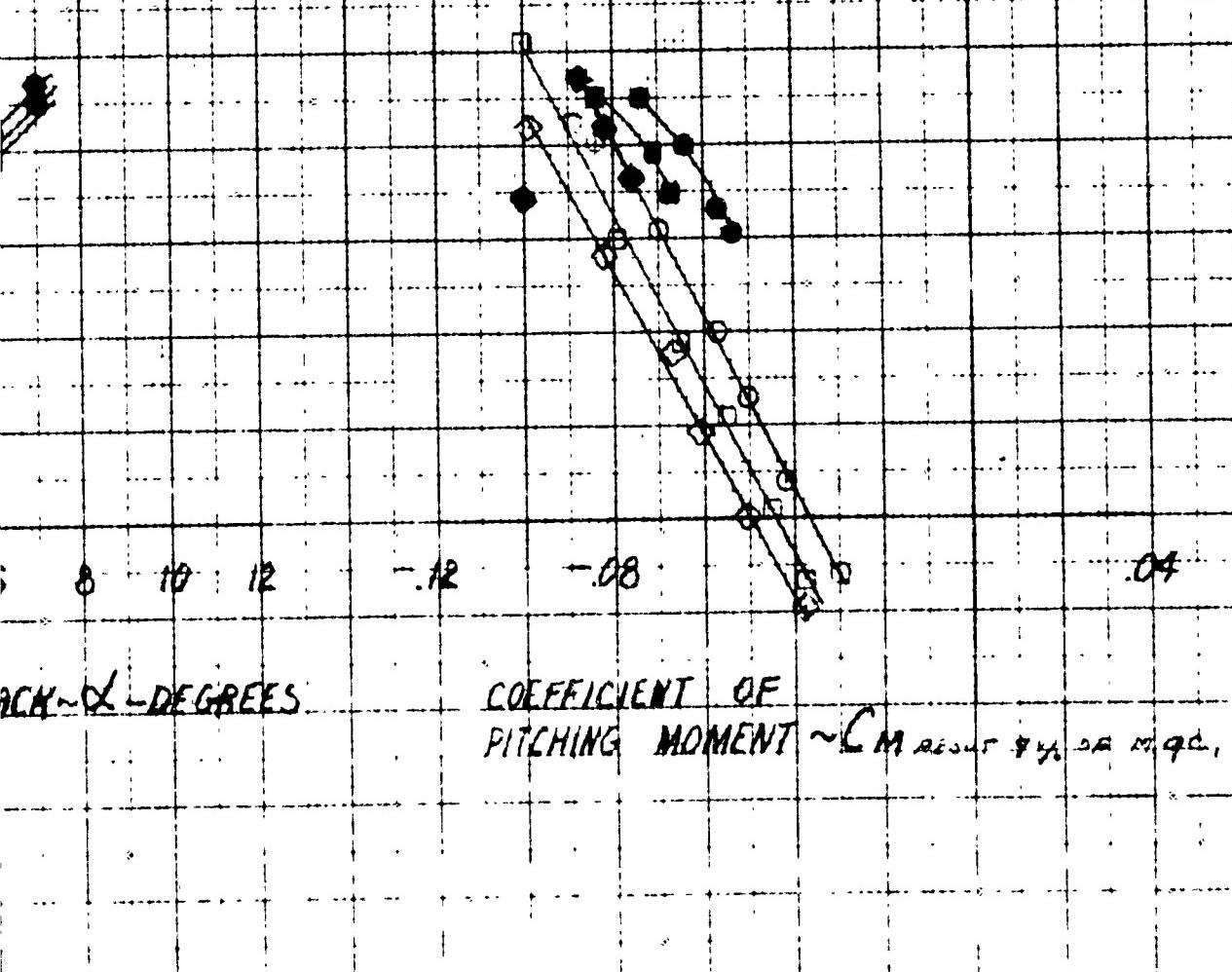
WHIRLING TANK TEST NO. 44

BU SHIPS FOIL NO. 15

MAC. = .152 FT AREA = 8.00 SQ. IN.

V = 45 KTS.

DARKENED SYMBOLS INDICATE
VENTED FLOW.



SYMBOLS & FIGURE NO. CALL NO.

0.75	812	339
1.00	932	356
1.25	970	357

NOTE:

COEFFICIENT OF LIFT C_L

5
4
3
2
1
0

COEFFICIENT OF DRAG C_D

.04 .05

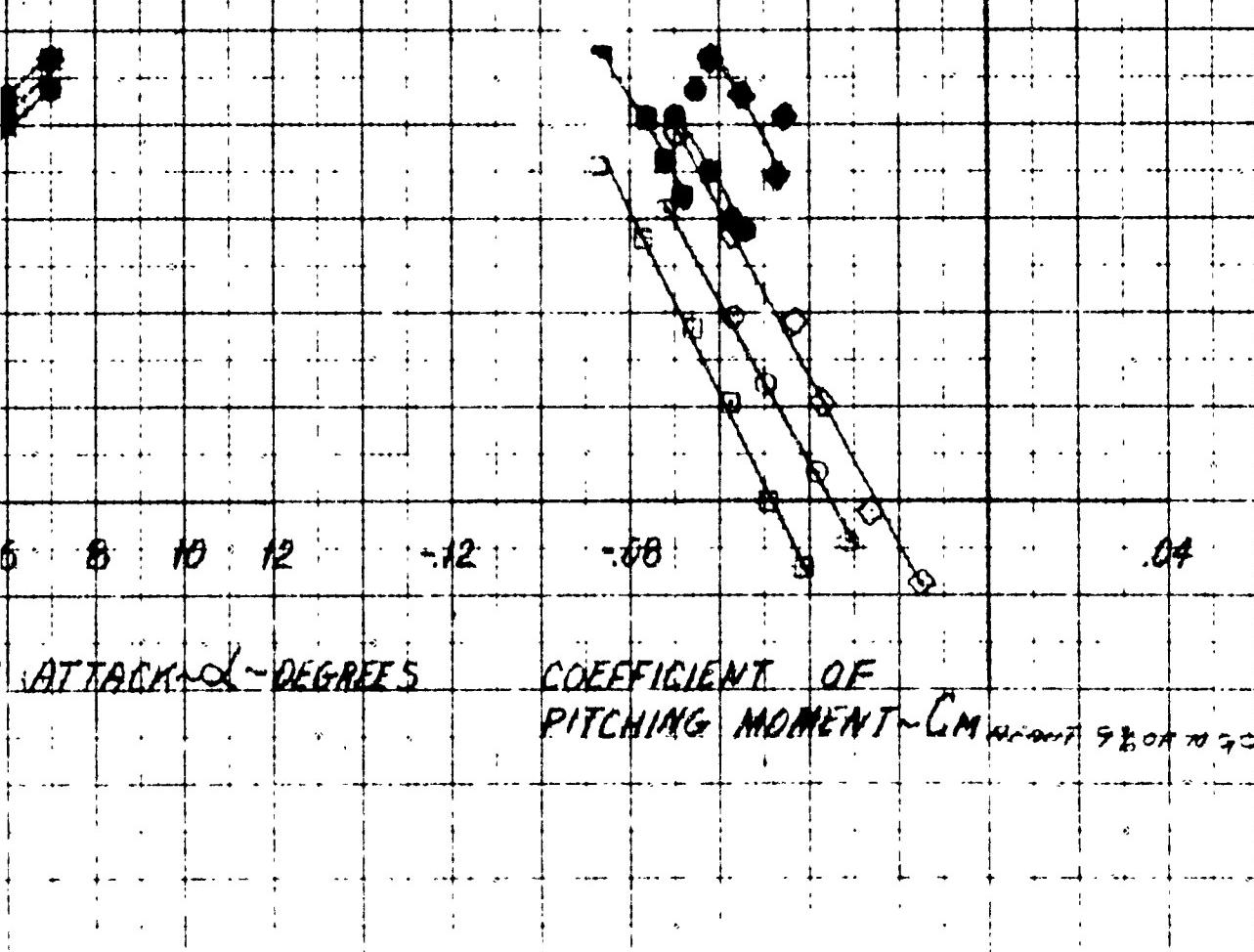
ANGLE OF ATT.

E.D.
V

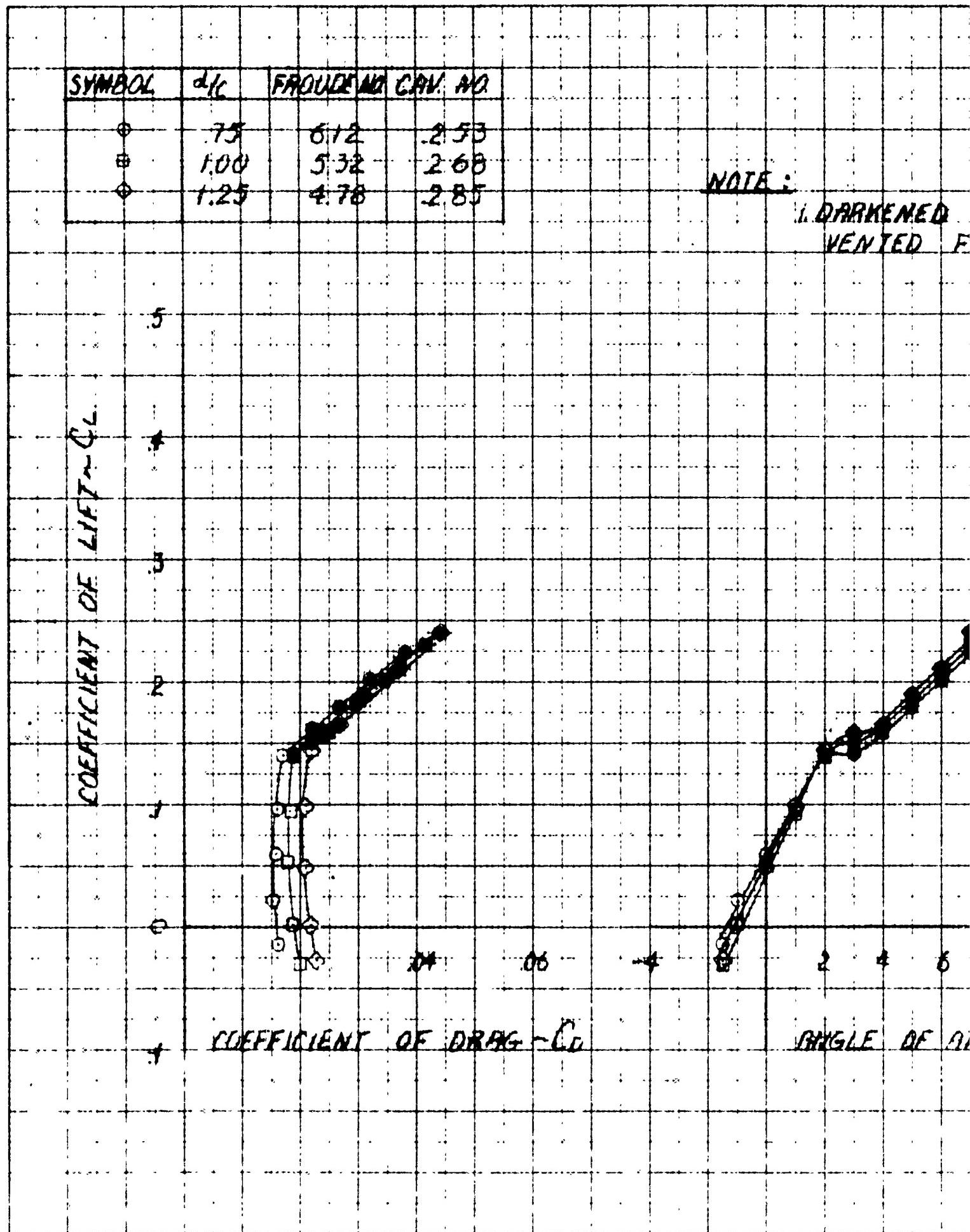
PAGE IV.80

WHIRLING TANK TEST NO. 44
BU SHIPS FOIL NO. 15
MAC = 152 FT. AREA = 8.00 SQ. FT.
 $V = 50$ KTS.

I. DARKENED SYMBOLS INDICATE
VENTED FLOW



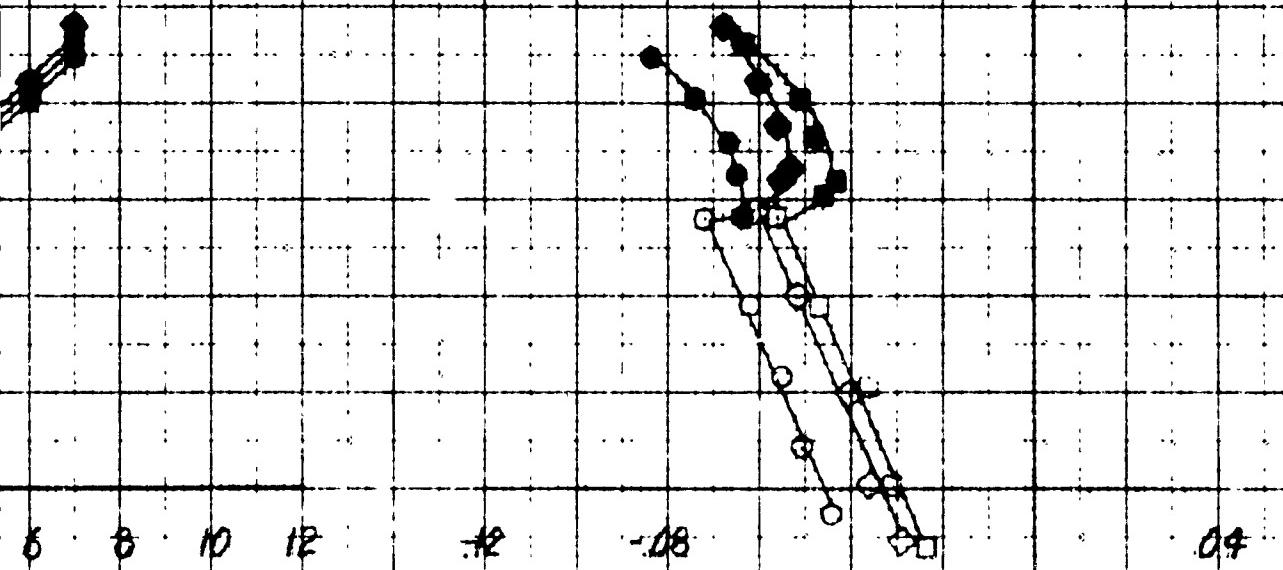
ATTACK ANGLE - DEGREES COEFFICIENT OF
PITCHING MOMENT - C_m FROM 5% DATA



PAGE 14, 81

WHIRLING TANK TEST NO. 44
BU SHIPS FOYL NO. 15
MAC = .152 FT. AREA = 3.00 SQ IN
V = 60 MTS.

ED SYMBOLS INDICATE
FLOW



ANGLE OF ATTACK - DEGREES
COEFFICIENT OF
PITCHING MOMENT - M (max 9% off axis)

SYMBOL d/c ATTITUDE AND GAGE HD

•	75	0.12	1.99
■	100	5.32	2.16
◆	125	4.76	2.32

NOTE:

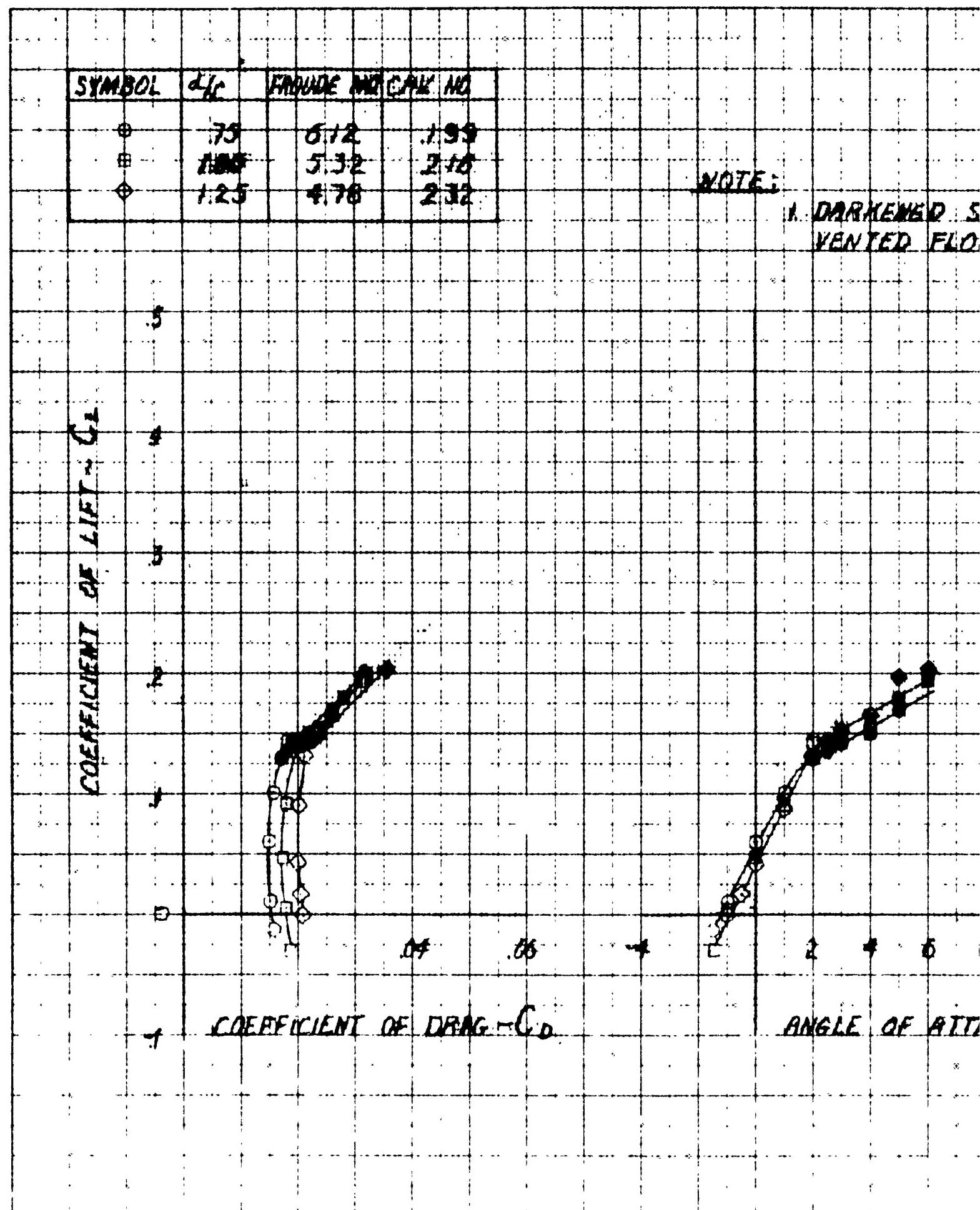
1. DARKENED S
VENTED FLO

COEFFICIENT OF LIFT - C_L

COEFFICIENT OF DRAG - C_D

COEFFICIENT OF DRAG - C_D

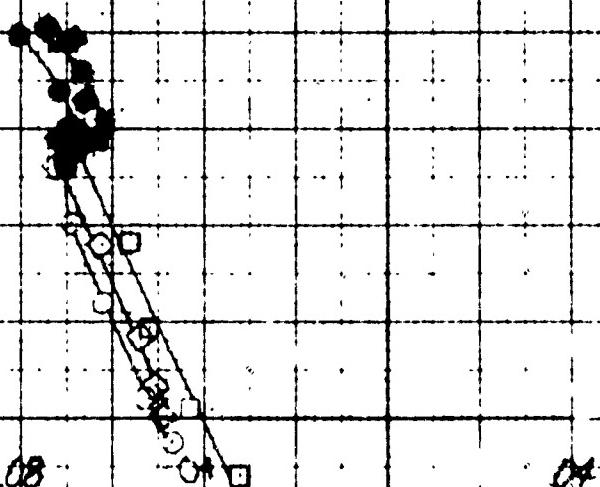
ANGLE OF ATT.



PAGE 1 KB2

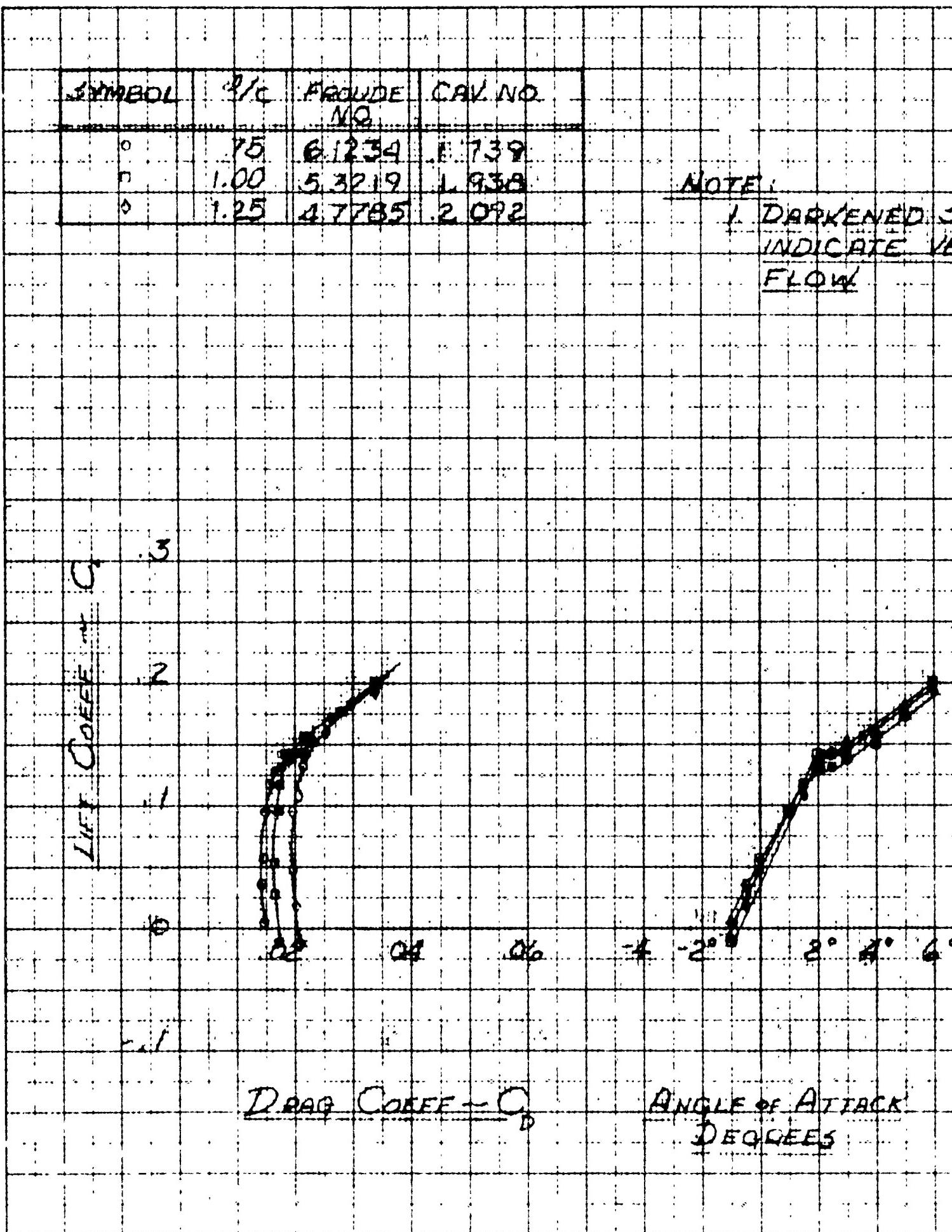
WHIRLING TANK TEST NO. 44
BU SNIPS FOIL NO. 15
MAC = 152 FT. AREA = 8.0052 FT.
 $V = 70$ M/S.

2. SYMBOLS INDICATE
FLOW



ATTACK - α - DEGREES

COEFFICIENT OF
PITCHING MOMENT - C_m at $\alpha = 0^\circ$



PAGE 16 B3

WHIRLING TANK TEST NO 44
BUSHIPS FOIL NO. 15
MAC = 1.52 FT AREA = 8.52 IN.

$$V = 80 \text{ KI} \cdot \text{SEC}$$

SYMBOLS
VENTED

RECORDED BY H. C. HANSON



6° 5° -0.8 -0.6 -0.4 -0.2

PITCHING MOMENT COEFF - C_M
ABOUT $\frac{1}{3}$ OF THE MAC

SYMBOL	α/α_c	FRICTION NO.	CAV NO.
o	.75	6.34	.488
+	.400	3.51	.510
o	.125	4.95	.525

NOTE:

1. DARK
INDIC.

ME Number 2022

COEFFICIENT OF DRAG - C_D

5

4

3

2

1

0

-1

-2

COEFFICIENT
OF DRAG

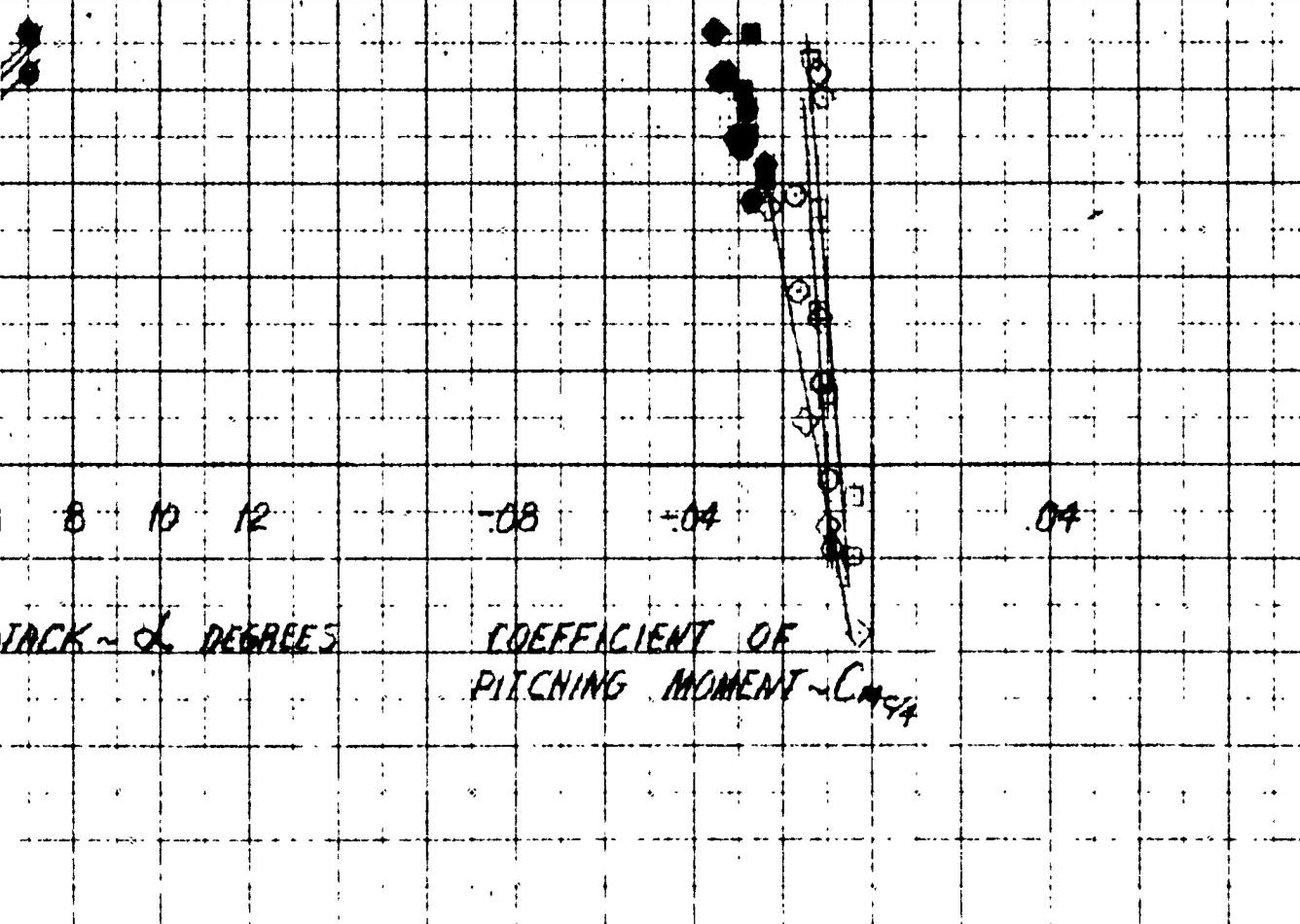
ANGLE OF ATTACK

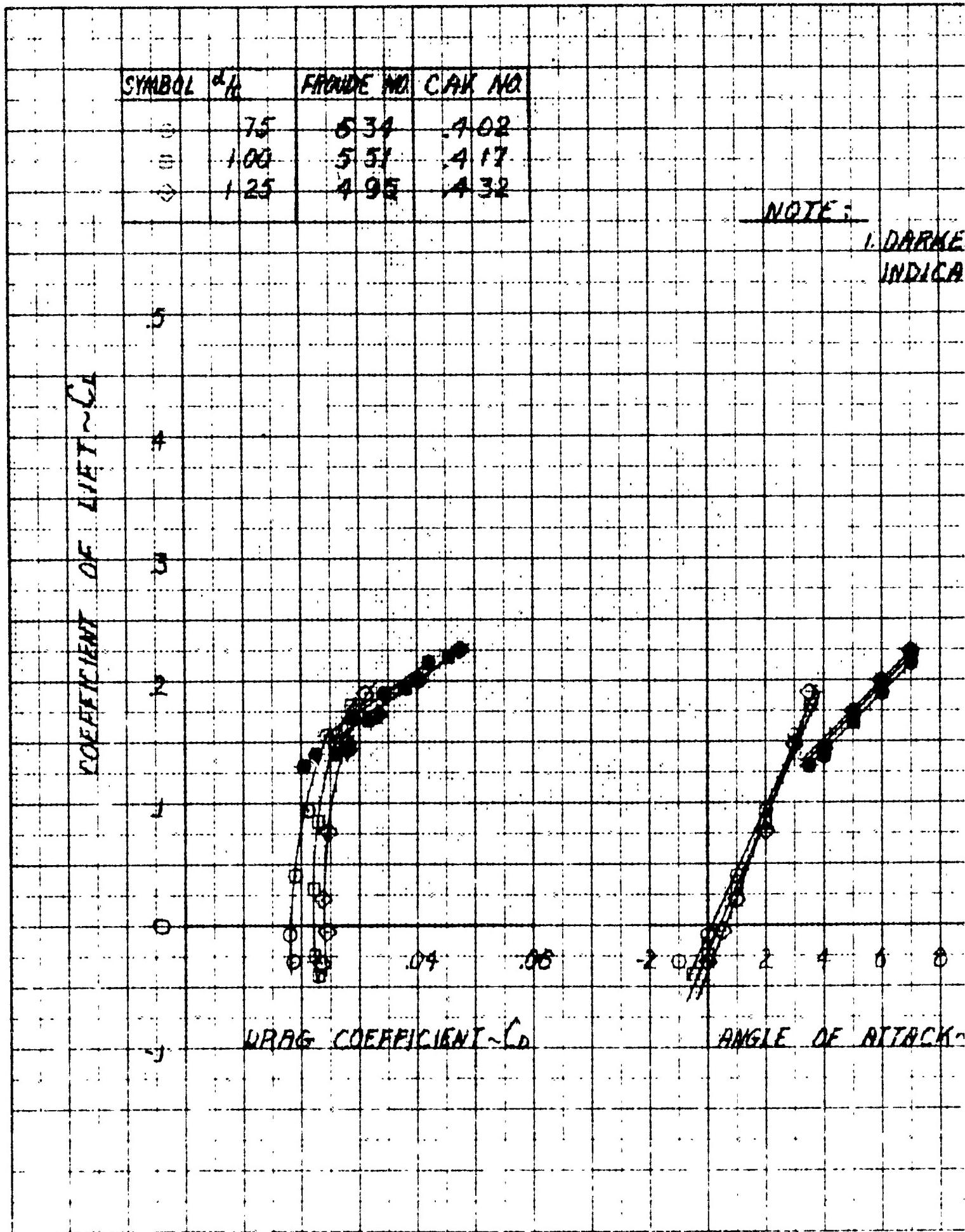
0.0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5

PAGE IV.24

WHIRLING TANK TEST NO 45
BU. SHIPS FOIL NO. 18
M.A.C. = 142 FT. AREA = 8.23 FT.
 $V = 40$ MTS.

ARKENED SYMOL'S
DICATE VENTED FLOW

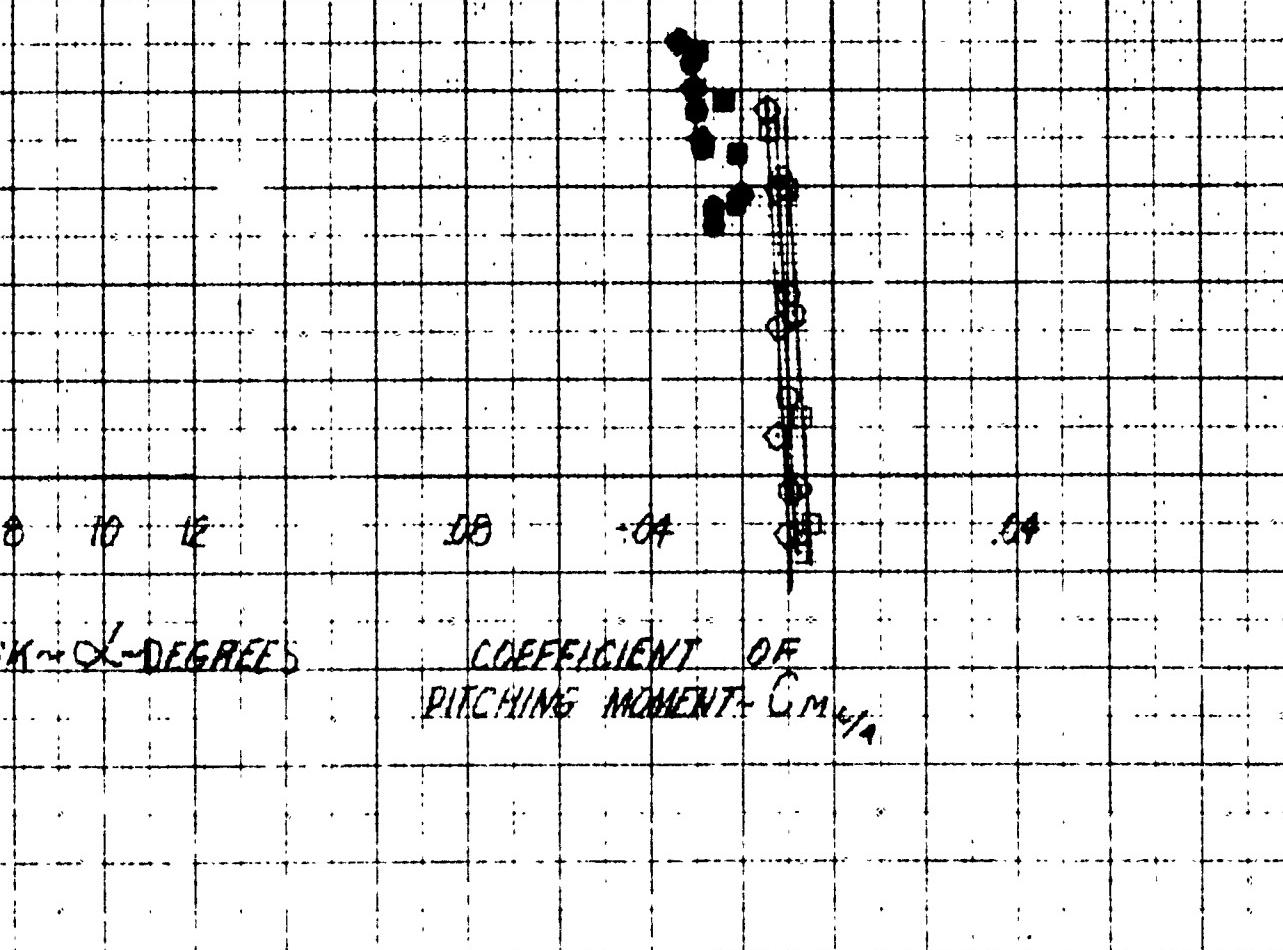




PAGE IV.55

WHIRLING TANK TEST NO. 20
BU SHAPS FOIL NO. 16
MAC = 142 FT. AREA = 8.23 FT.²
 $V = 45 \text{ FT.S.}$

USED SYMBOLS
CATE VENTED FLOW.



$\alpha = 0^\circ$ -DEGREES

COEFFICIENT OF
PITCHING MOMENT - C_M

SYMBOL	d/c	FREUDEN NO.	CAN NO.
○	.75	8.34	3.35
□	1.00	5.51	3.80
◊	1.25	4.95	3.60

NOTE:

1. DARKENED
INDICATE REM

COEFFICIENT OF LIFT - C_L

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

DRAg COEFFICIENT - C_D

ANGLE OF ATTACK -

PAGE IV.86

WHIRLING TANK TEST NO. 46
BLI SHIPS. FONL NO. 16
MAC = 142 FT AREA = 0.23 m²
V = 50 KTS.

SYMBOLS
VENTED FLOW

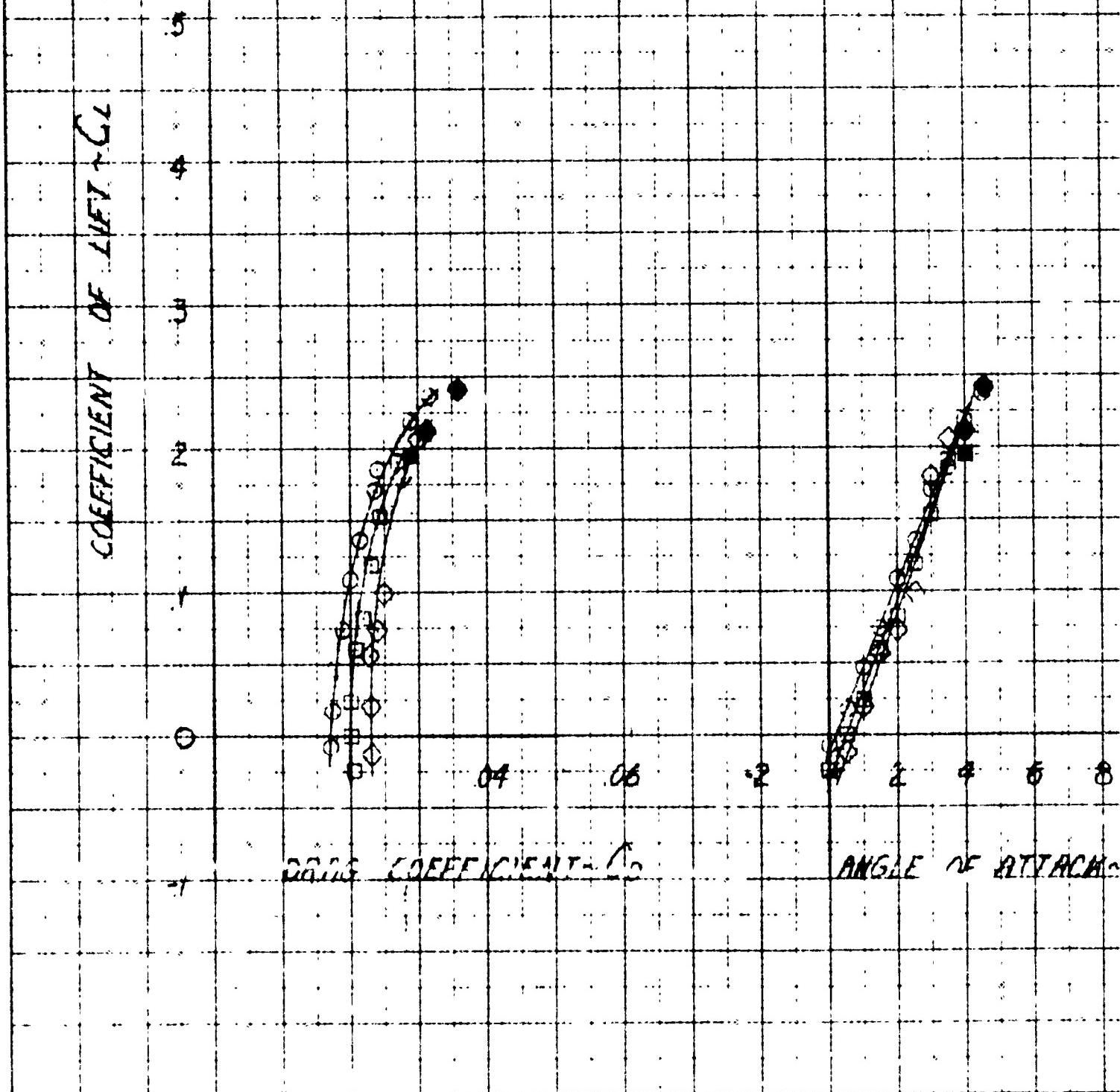
10 12 -08 -07 04

W = 0 DEGREES COEFFICIENT OF
PITCHING MOMENT C_M

SYMBOL	d / c	FROUDE NO.	CAV. NO.
•	75	6.34	.2 48
□	1.00	5.51	.2 63
◊	1.25	4.95	.2 78

NOTE:

1. DARKHEADED
INDICATE



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WHIRLING TANK TEST NO. 46

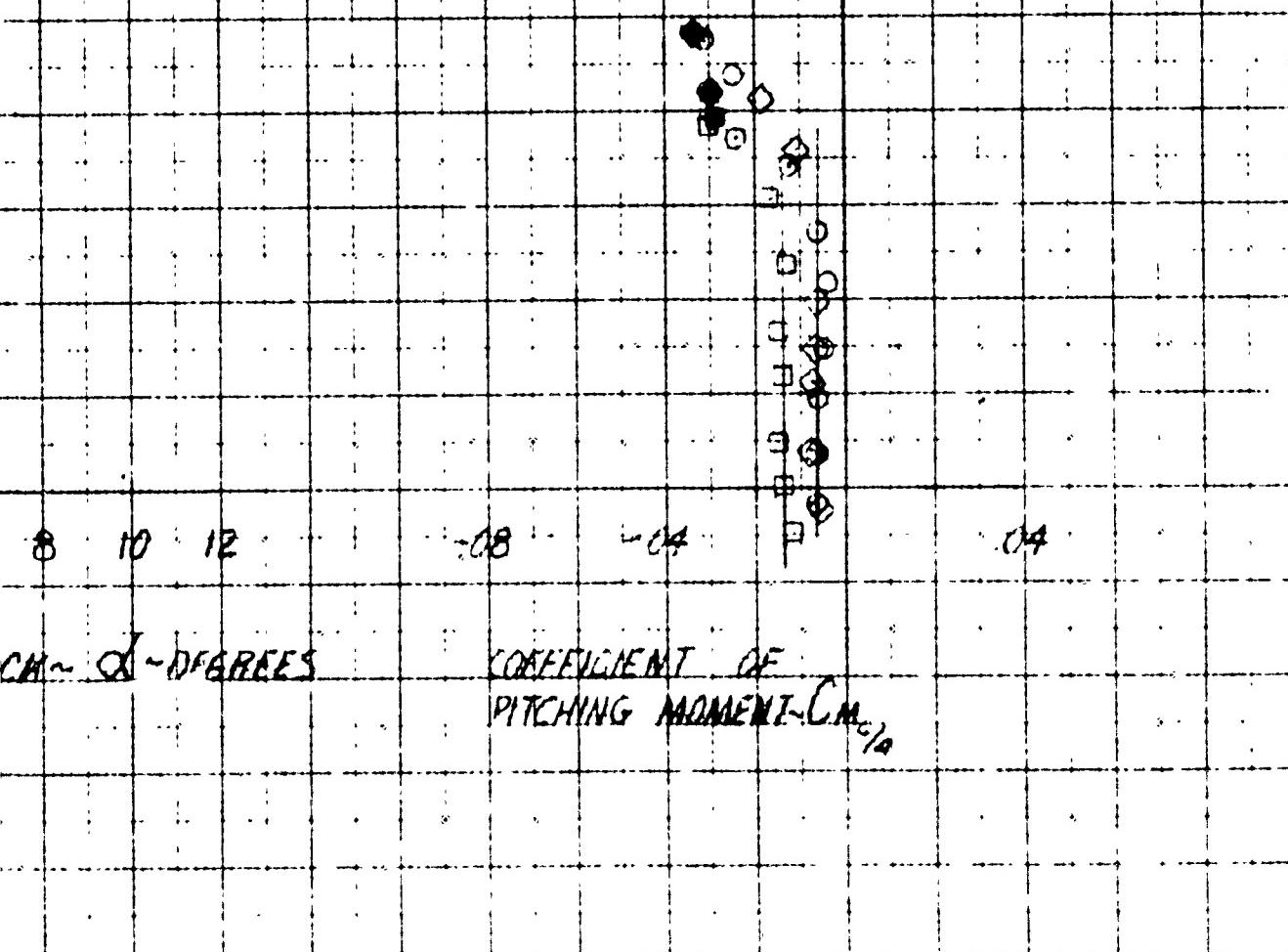
BU SHIPS FOIL NO. 16

W.L.C = 142 FT. AREA = 8.23 IN²

V = 60 KTS.

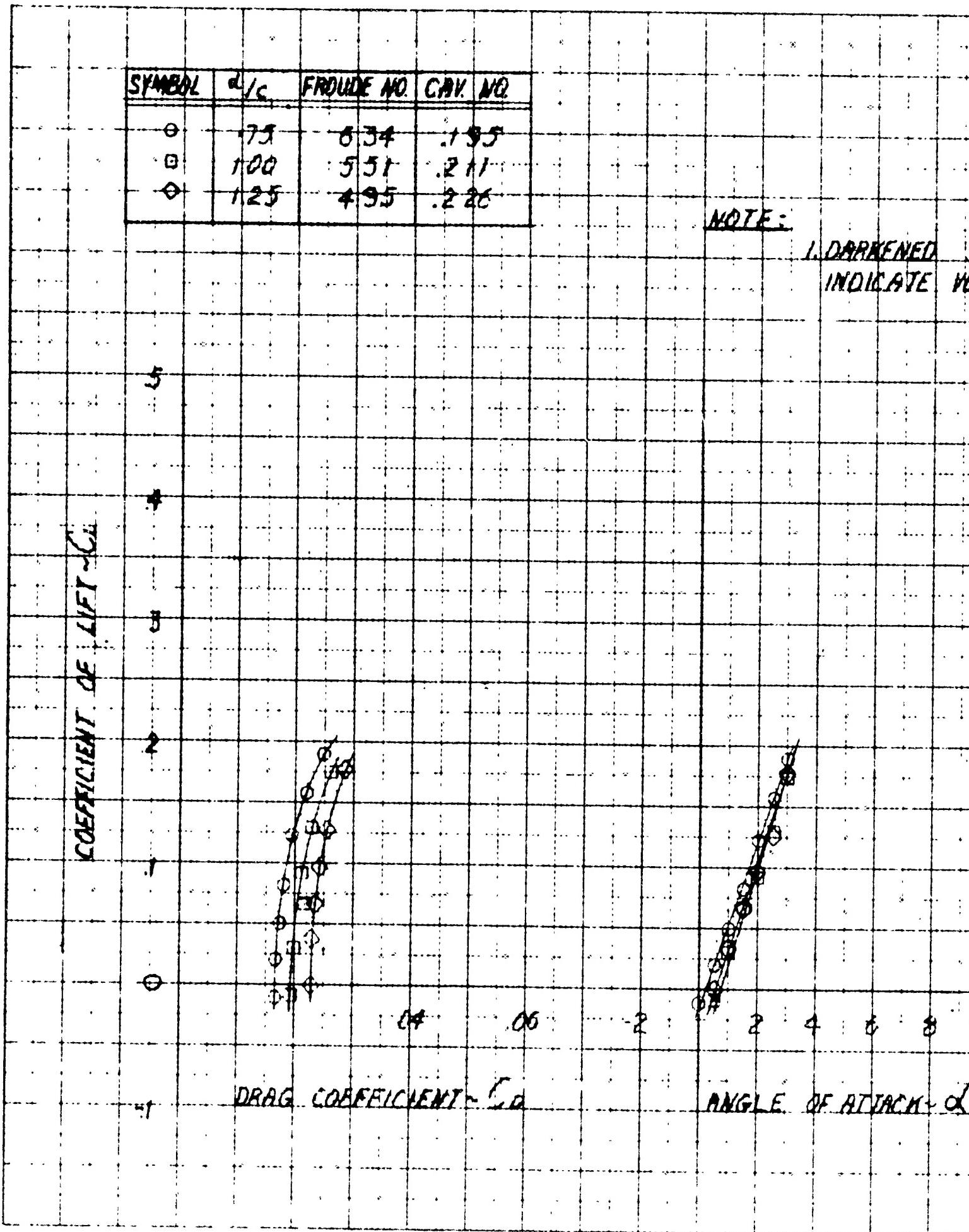
ED SYMBOLS

F VENTED FLOW



CM = 01 - DEGREES

COEFFICIENT OF
PITCHING MOMENT - CM

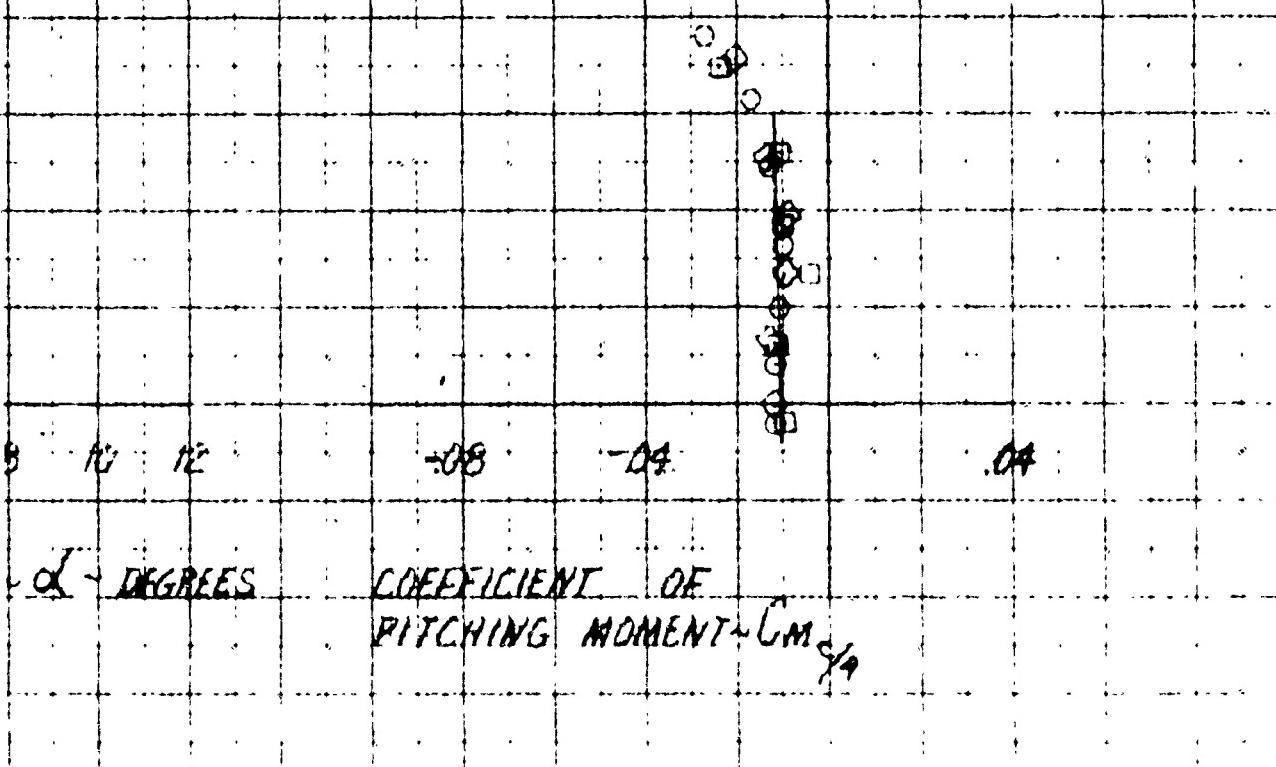


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WHIRLING TANK TEST NO 46.
BU SHIPS FOIL NO 16.
MAC = 142 FT. AREA = 8.23 IN².
 $V = 70 \text{ FT.S.}$

SYMBOLS

HEATED FLOW

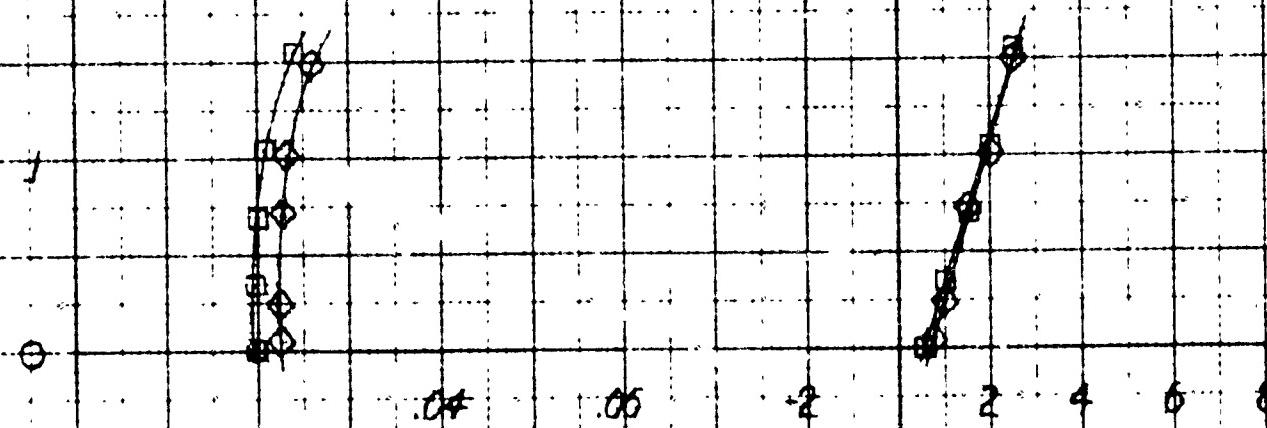


SYMBOL	d/c	FROUDE NO	CAV. NO
→	75	5.51	.177
↔	100	4.95	.192
⇒	125		

NOTE:

1. DARKENED
INDICATE

LIFT COEFFICIENT - C_L



DRAG COEFFICIENT - C_D

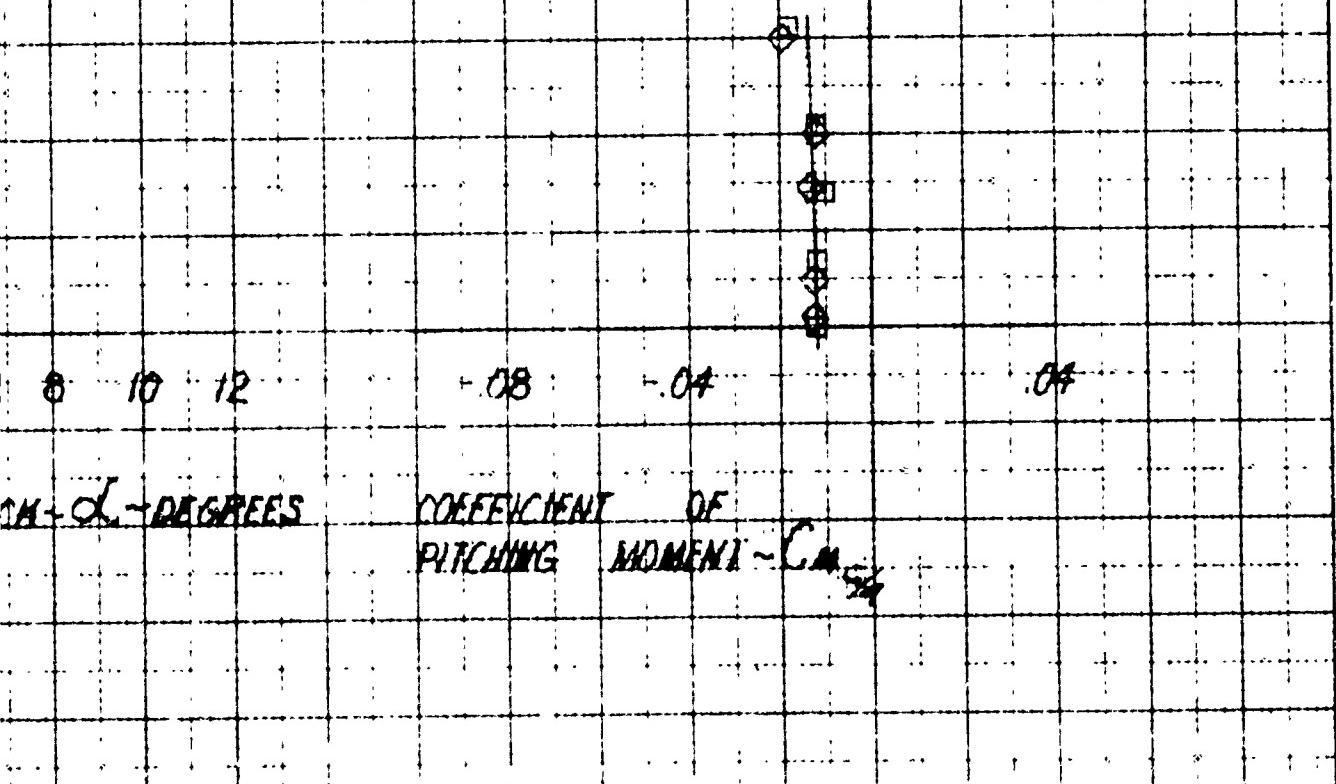
ANGLE OF ATTACK

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WHIRLING TANK TEST NO. 46
BU SHIPS FOIL MD. 16
MACH. 142 FT. AREA = 8.23 m^2
 $V = 80 \text{ KTS.}$

2 SYMBOLS

VENTED FLOW.

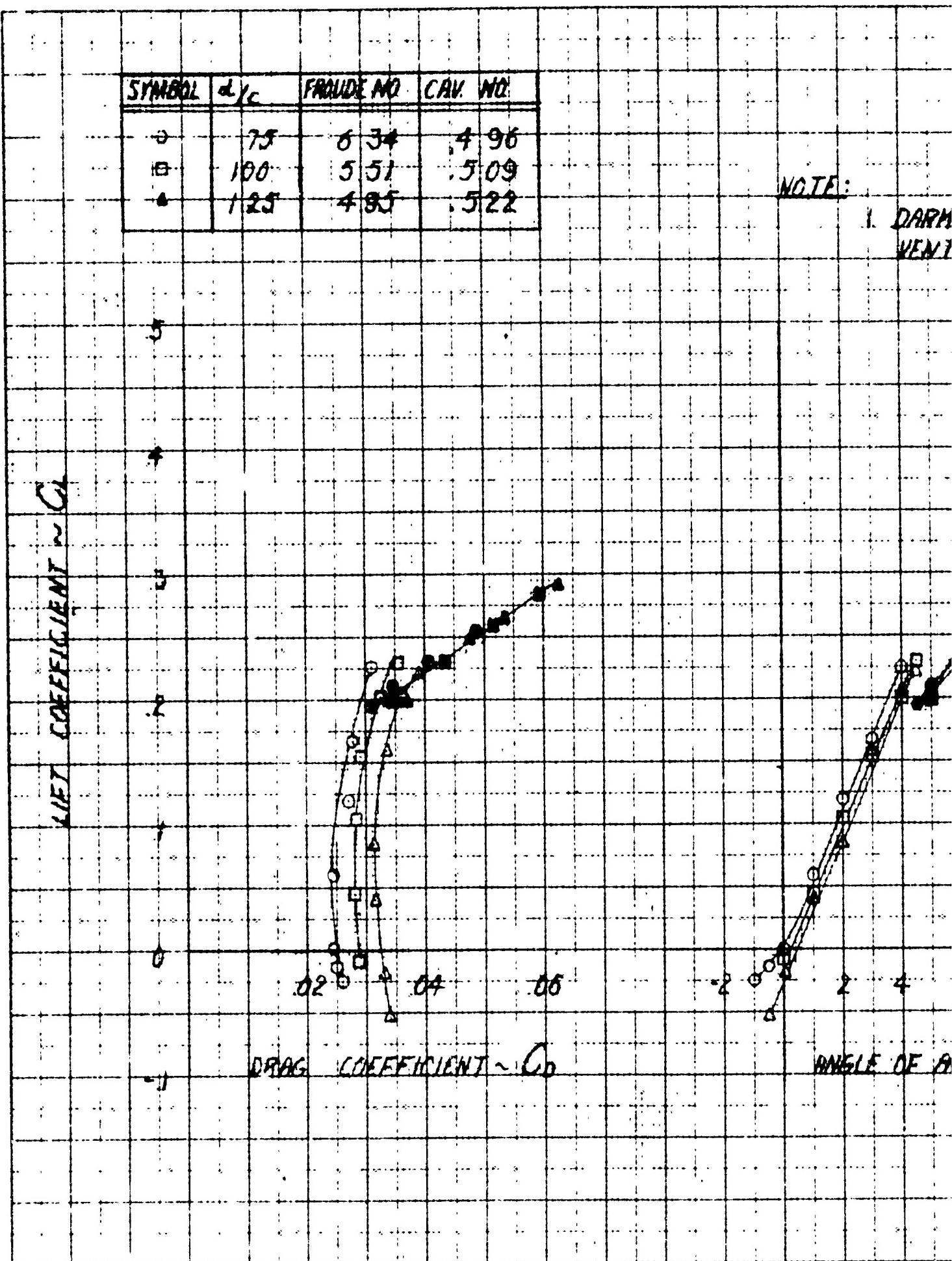


SYMBOL	d/c	FRAUD NO	CAV. NO
○	75	834	496
□	100	551	509
●	125	485	522

NOTE:

1. DARM
VEN 7

K-E GUNNARSON 12/67



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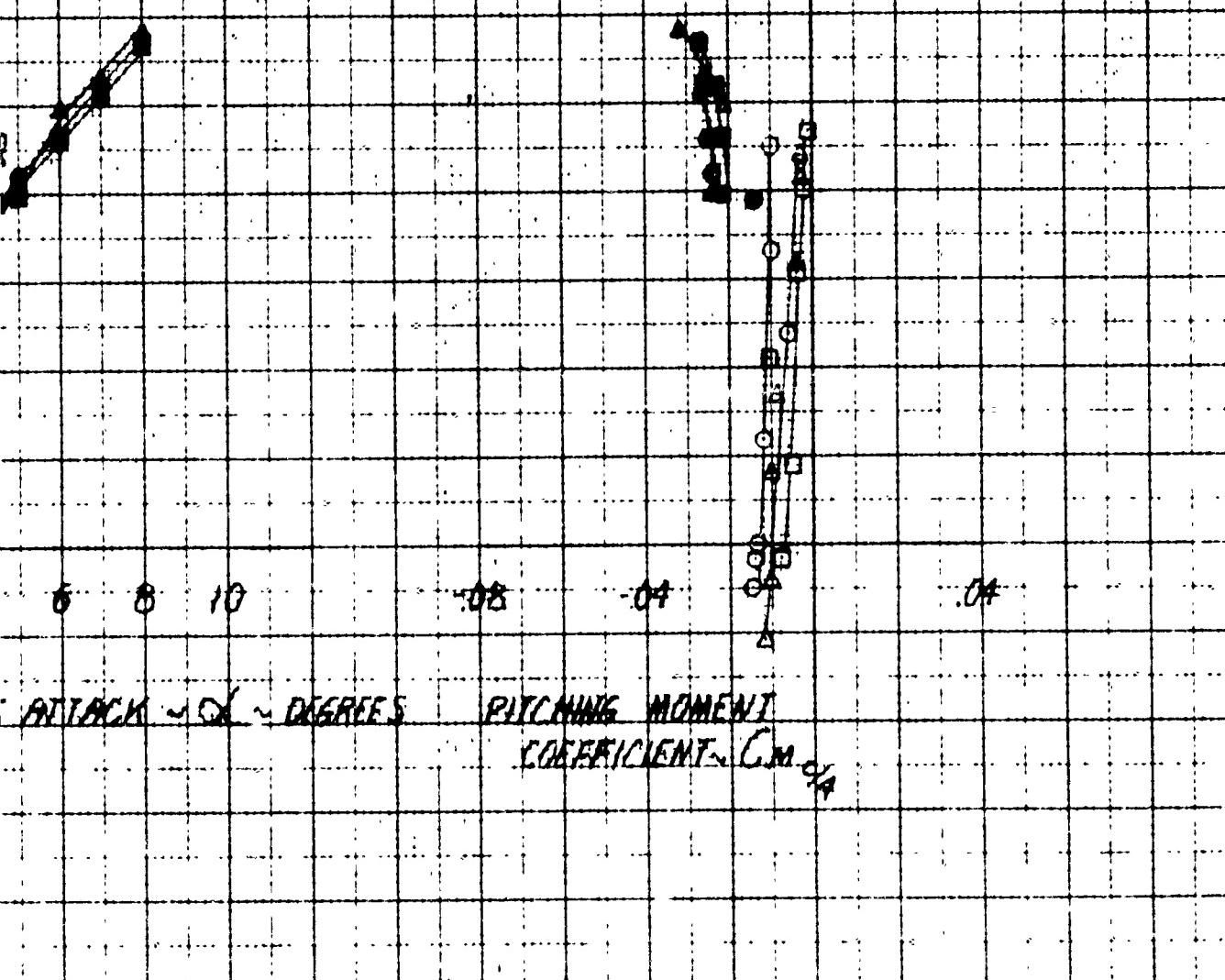
WHIRLING TANK TEST NO. 47

BU SHIPS FOIL NO. 17

$S = 8.23 \text{ in}^2$; $MAC = 142 \text{ EI}$

$V = 40 \text{ MTS}$

ARMED POINTS INDICATE
INTENDED FLOW



ATTACK ~ α ~ DEGREES

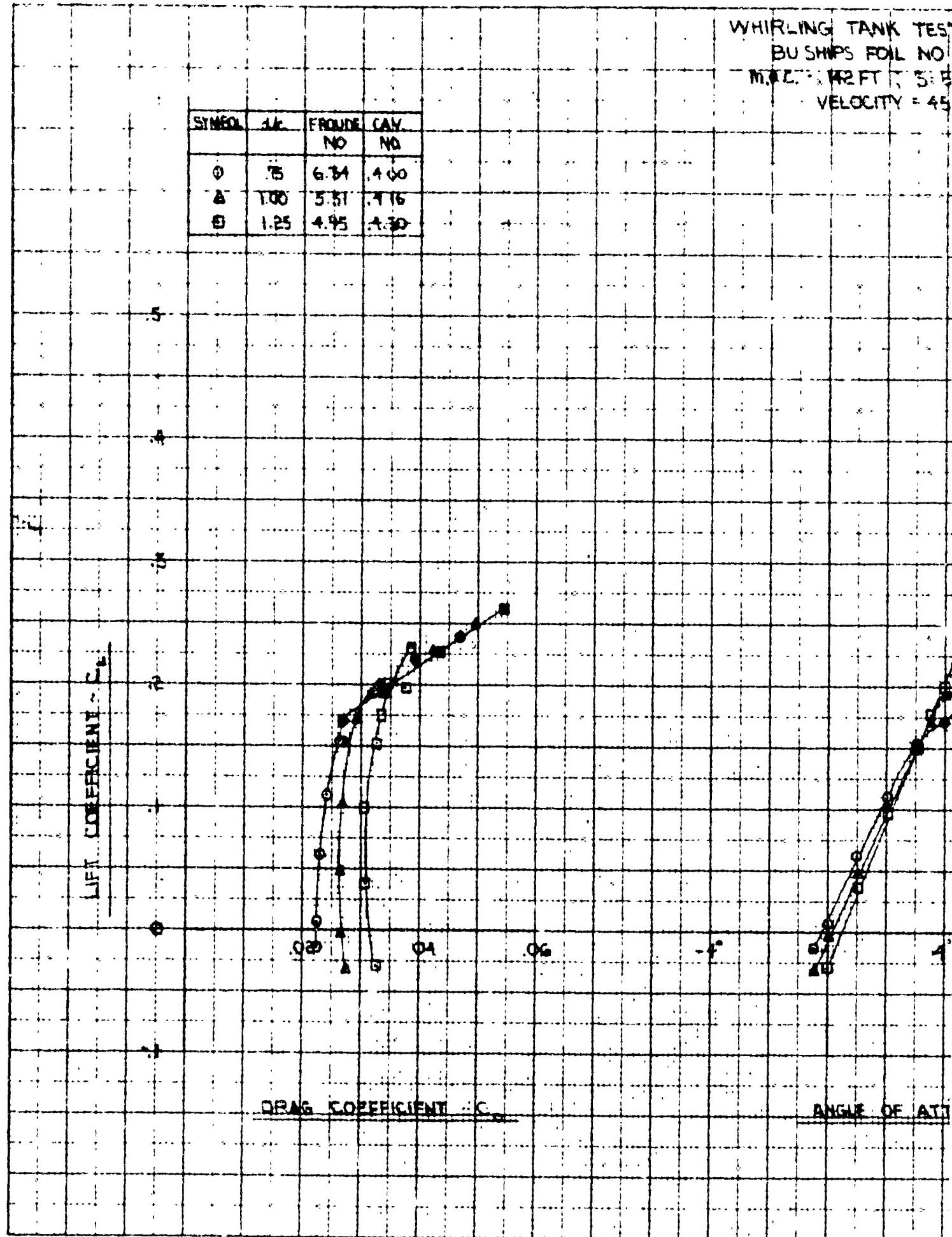
PITCHING MOMENT

COEFFICIENT, C_m

WHIRLING TANK TEST
BU SHIPS FOIL NO 17
M.A.C. = 142 FT. S.H. 2
VELOCITY = 45 K

SYMBOL	ΔL	FROUDE CAM. NO	NO
○	.75	6.34	.400
▲	1.00	5.51	.416
◎	1.25	4.45	.430

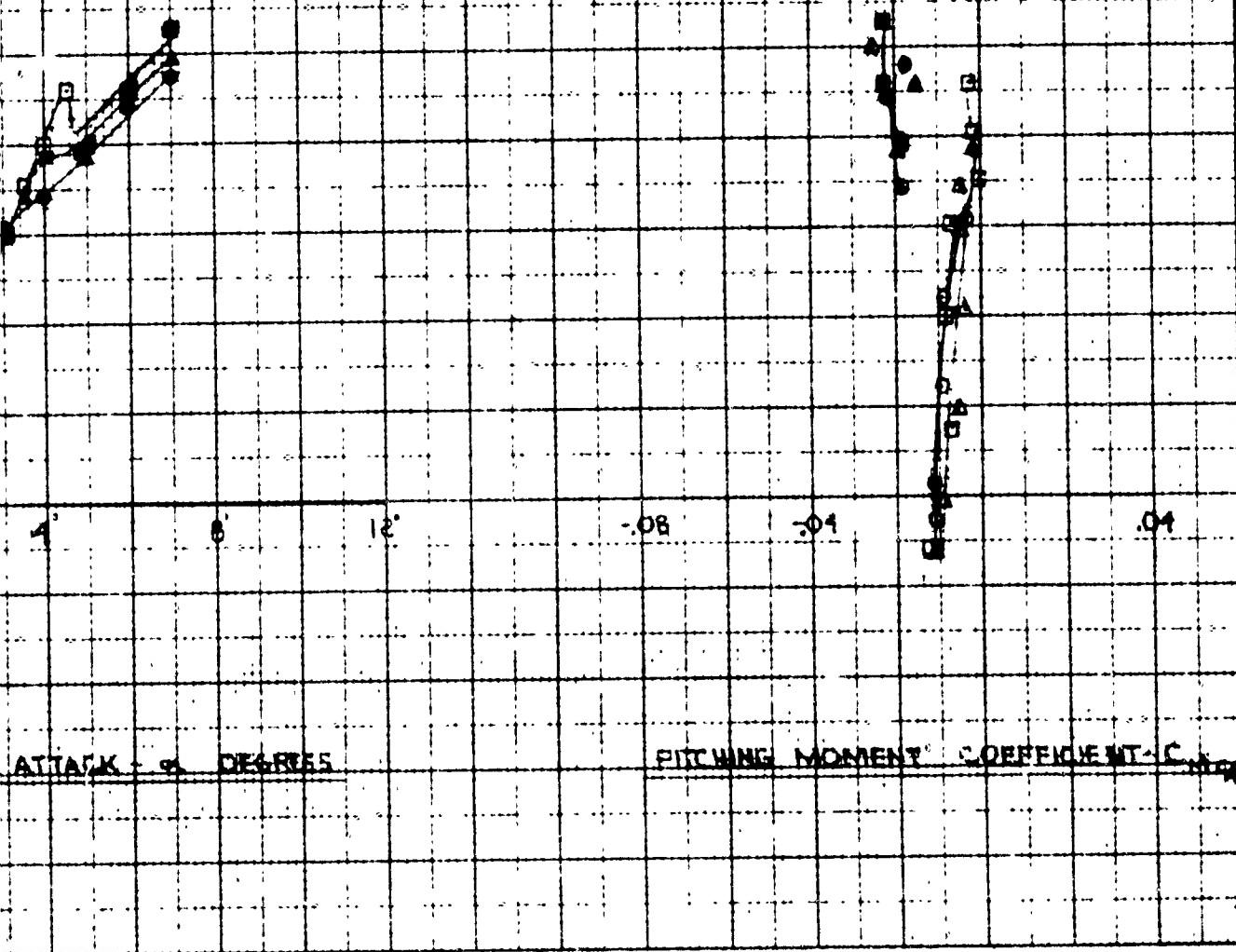
HOE STANDARDS TEST 52212



TEST NO. 47
10/17
H.253G IN
45 KTS

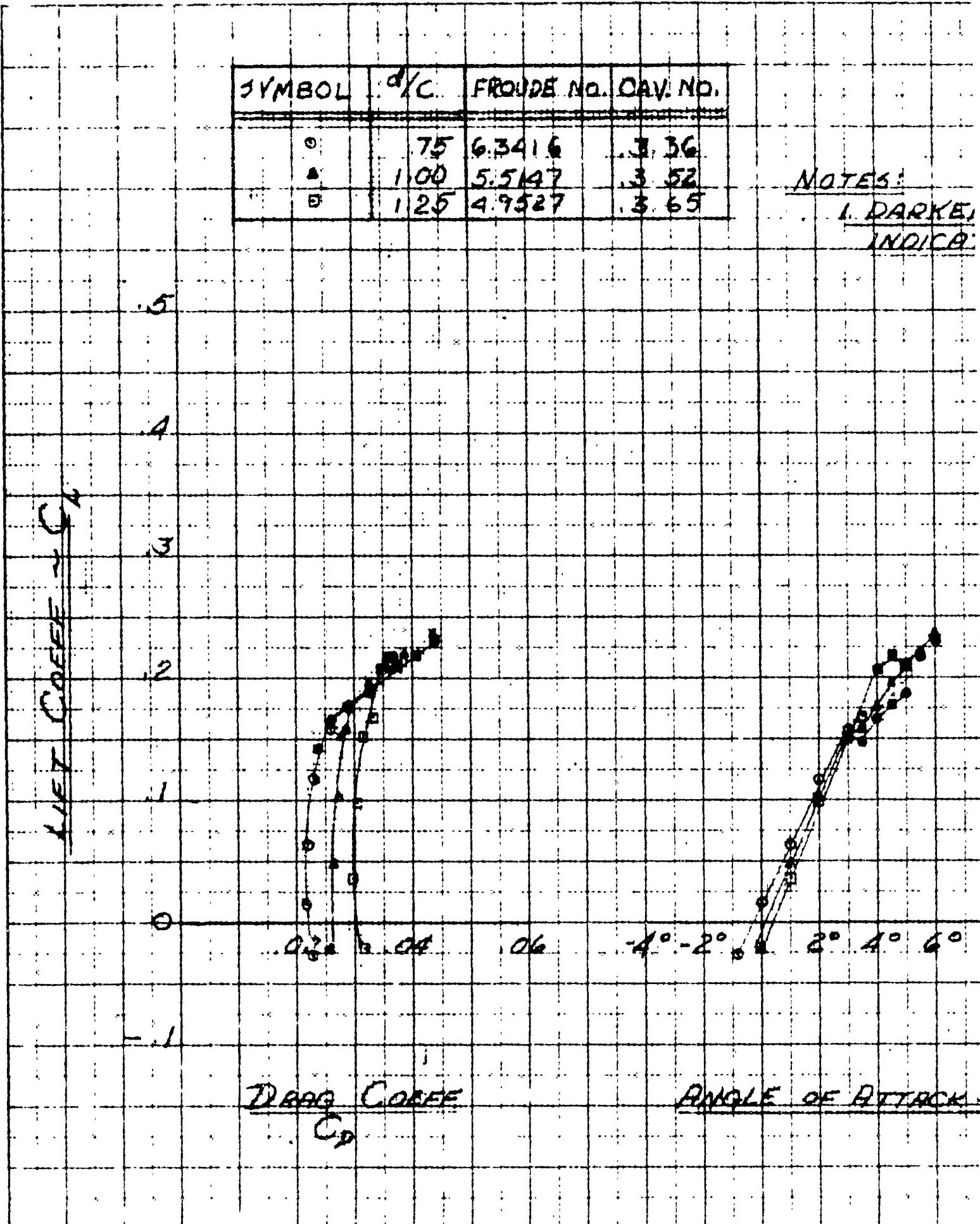
PAGE IV, 91

NOTE: DARKENED POINTS INDICATE VENTED FLOW



ATTACK ANGLE DEGREES

PITCHING MOMENT COEFFICIENT C_M



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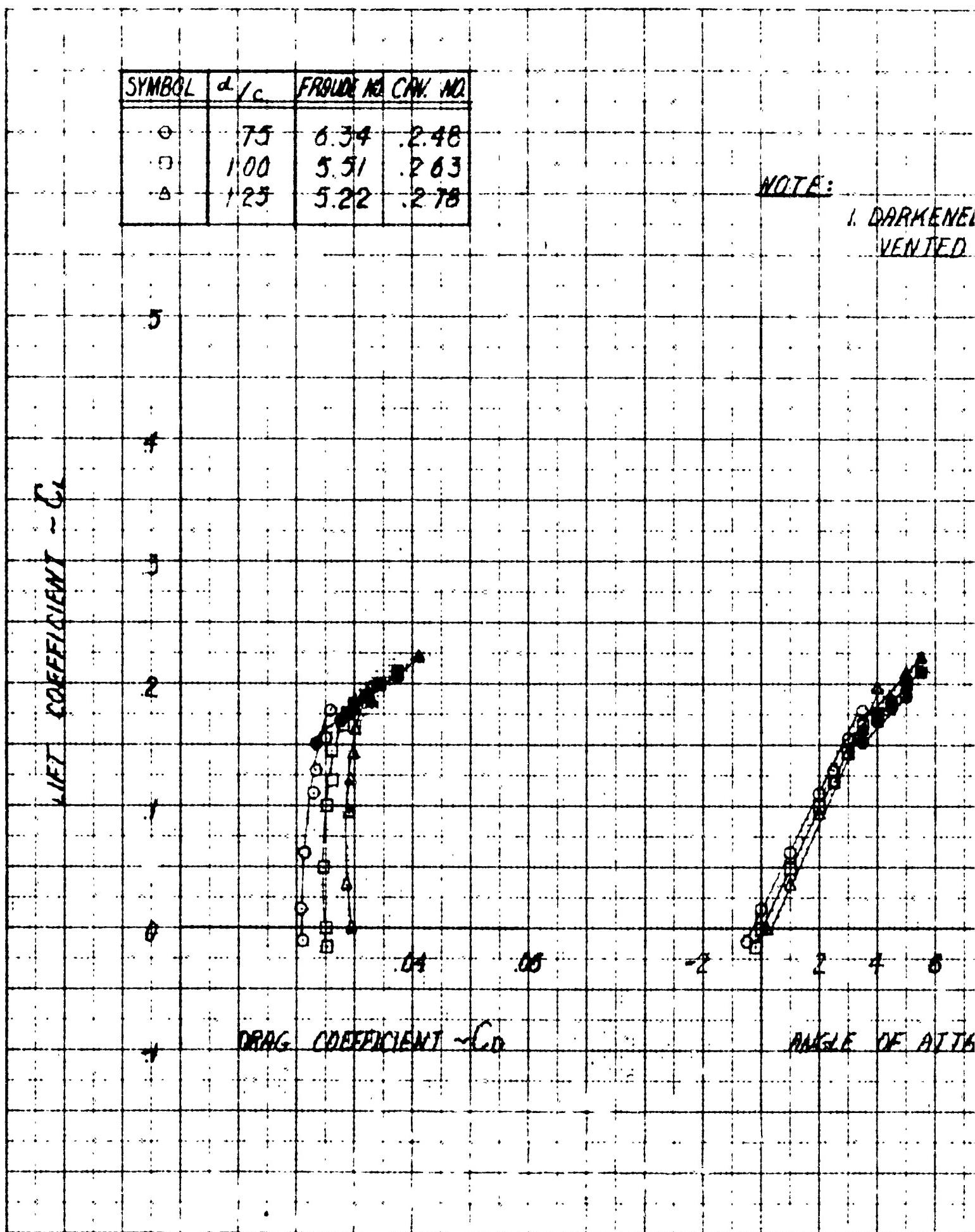
W.I.T. NO 47 BUSHIPS FOIL NO 17
M.A.C. 102 FT. AREA = 0.23⁰"
VEL. = 50 KTS.

KENED SYMBOLS
CATE VENTED FLOW

0 8° 10° 12° -08 -06 +04

+1 - DEGREES

PITCHING MOMENT COEFF - C_M



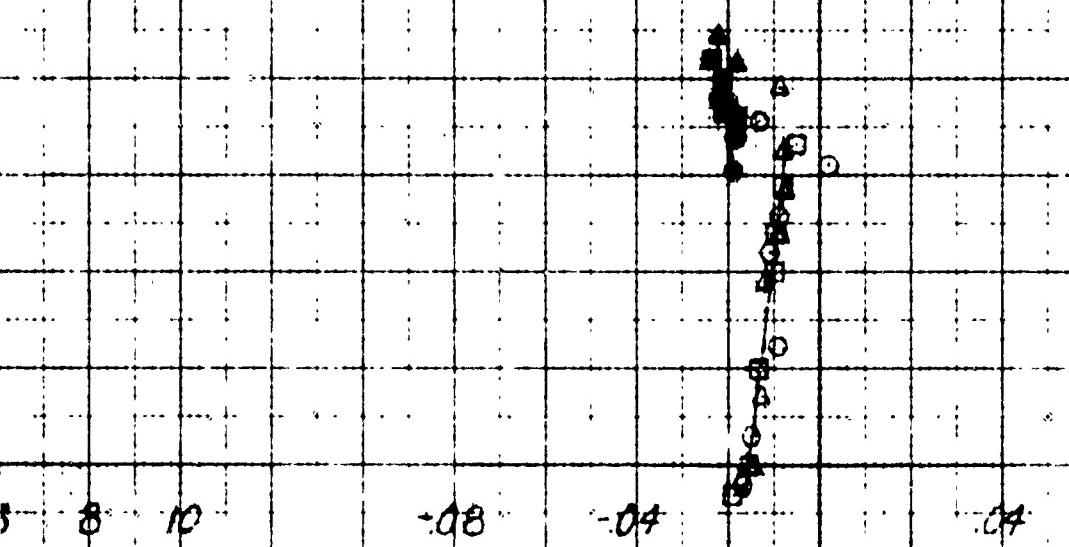
WHIRLING TANK TEST NO. 47

BU SHIPS EGIL NO 17

MAC = .142 FT ; S = 8.23 IN²

V = 60 FT/S PAGE 193

ENED POINTS INDICATE
ED FLOW



ATTACH + CX - DEGREES

PITCHING MOMENT

COEFFICIENT - CM₃₂

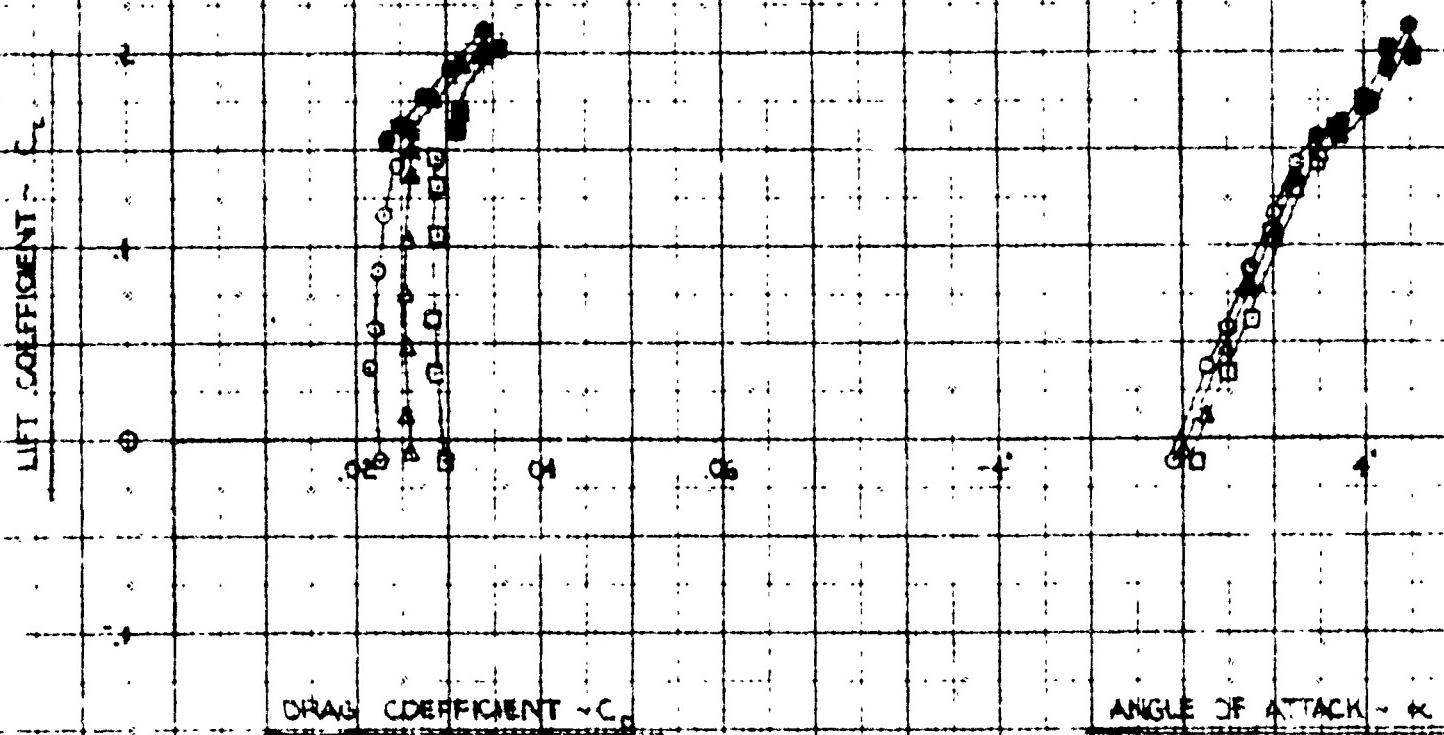
WHIRLING TANK TEST NO. 41

BU SHIPS FOIL NO. 17

M.O.C. .142 FT. S. 8.23 SQ IN

VELOCITY - 10 KTS

SYMBOL	A/E	FRONDS	CAY.	NO	NO
○	.75	6.34	.1%		
△	1.00	5.51	.2%		
□	1.25	4.95	.2%		



ANGLE OF ATTACK - α

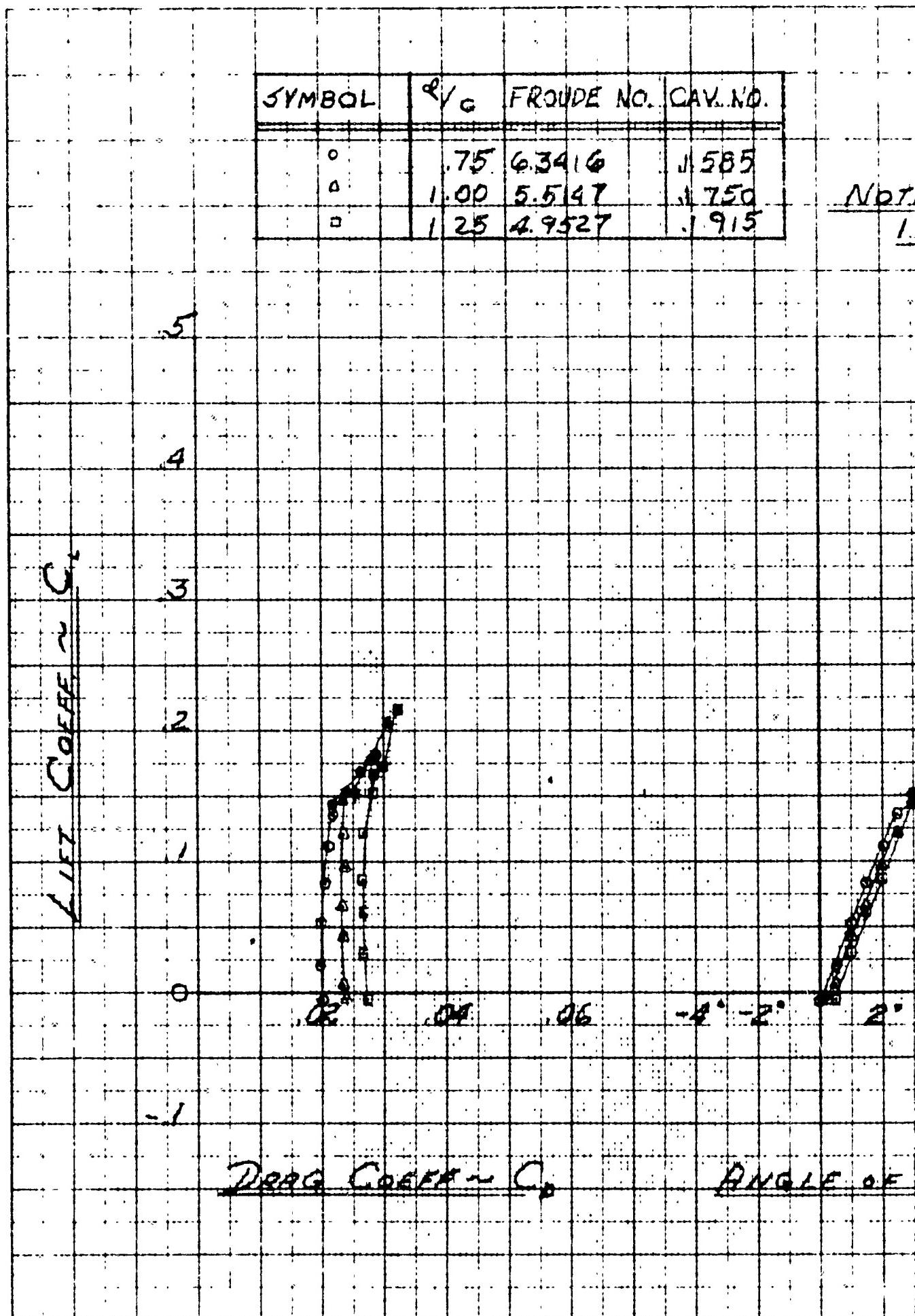
PAGE 1494

NOTE: DARKENED POINTS INDICATE VENTED FLOW.

12° -08 -04 00 04

X DEGREES

PITCHING MOMENT COEFFICIENT - C_m

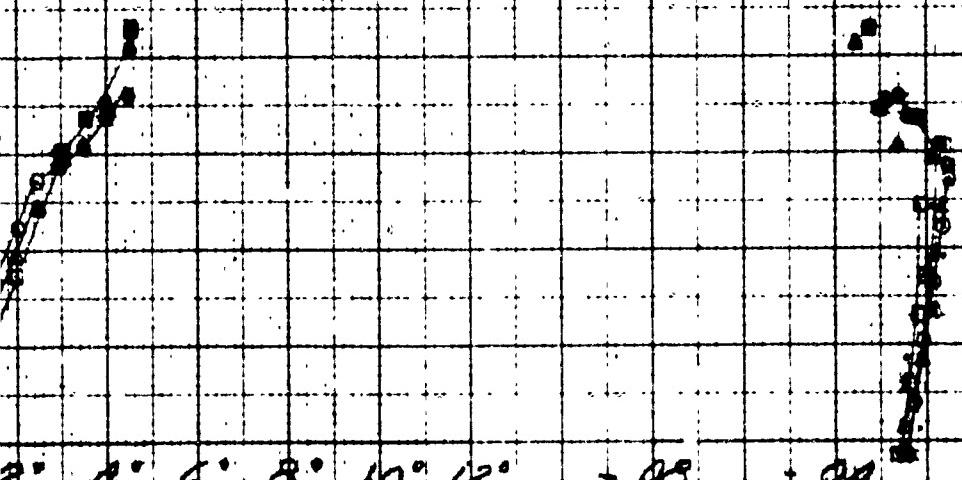


PAGE IV.95

W.T.I. NO. 47 BUSHIPS FOIL NO. 17
M.A.C. 142 FT. AREA = 8.23 Δ "
VEL = 80 KTS

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.

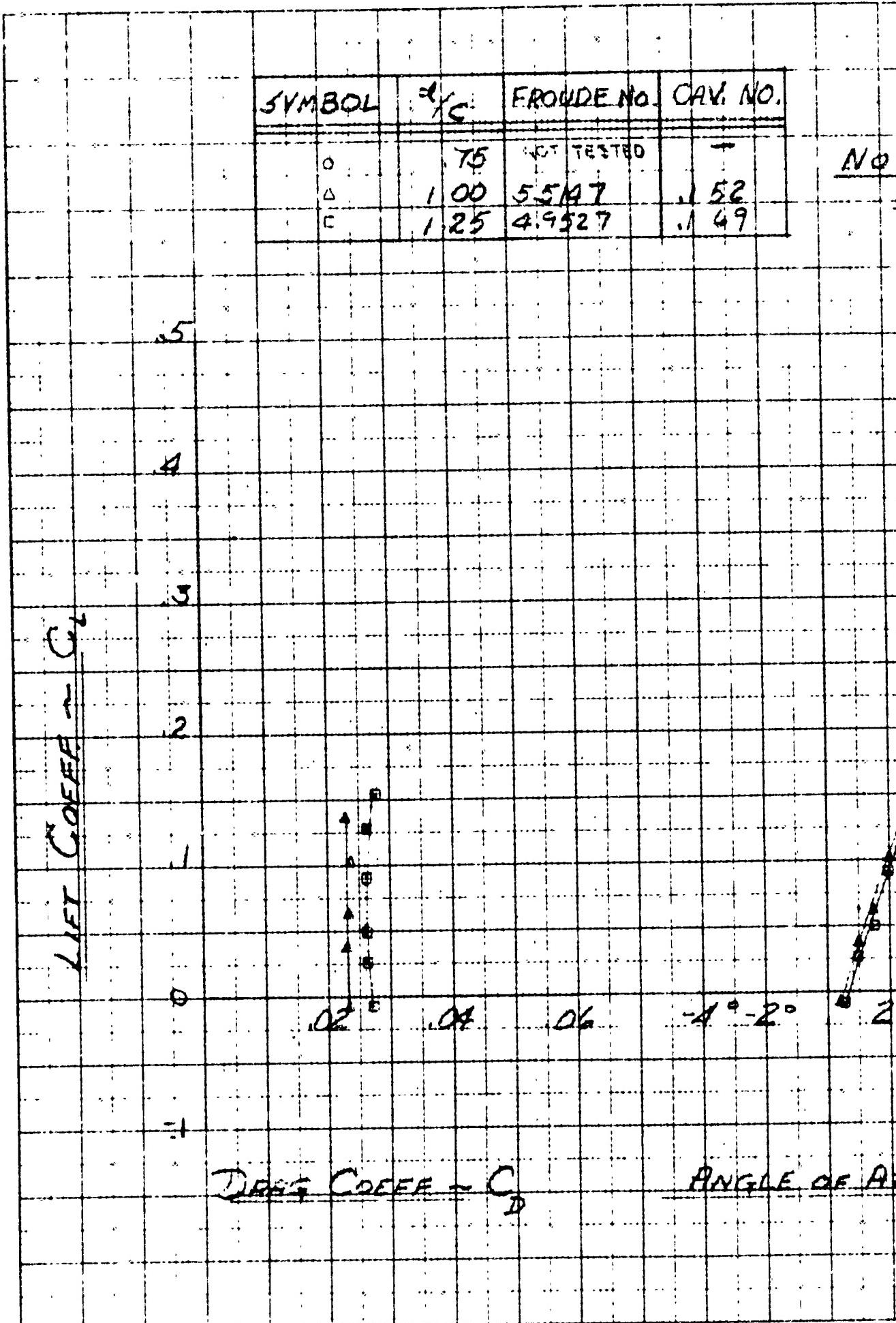


2° 4° 6° 8° 10° 12° +.03 -.03 .03

OF ATTACK - DEGREES

PITCHING MOMENT COEFF ~ C_M

24

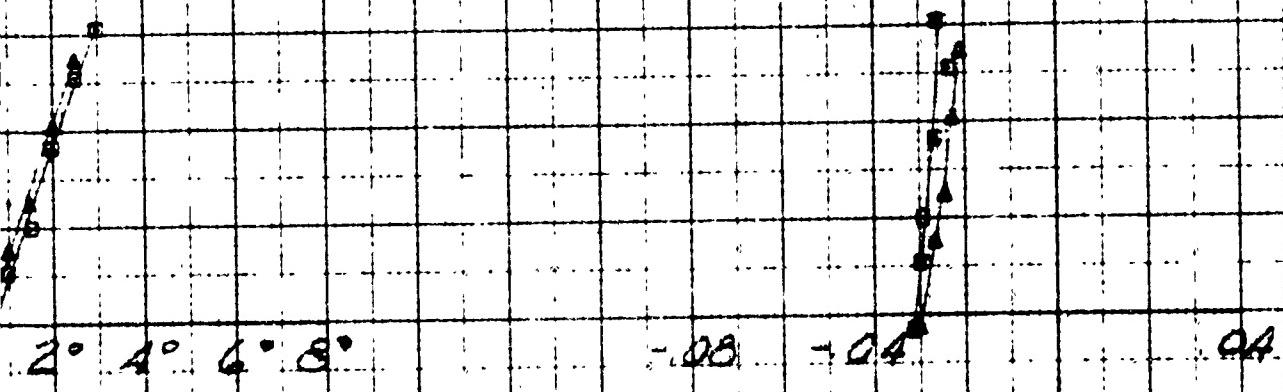


PAGE 1495

W.I.T. NO. 47 BUSHIPS FOIL NO. 17
MAC = 102 FT. AREA = 8.230"
VEL = 90 KTS

VOTES:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.



2° 1° 0° -1° -2°

-0.5 -0.4 -0.3

ATTACK DEGREES

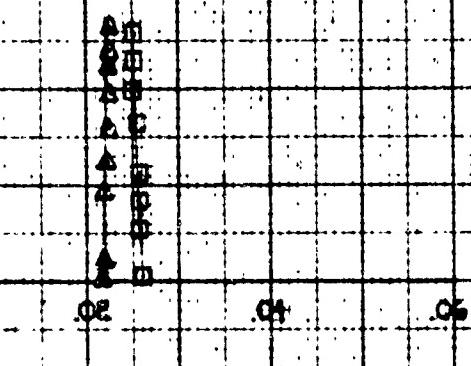
PITCHING MOMENT COEFF - C_m %

WHIRLING TANK TEST
BU SNAPS FOIL NO.
MAX. .142 FT 5°
VELOCITY 96 K

SYMBOL	A/C	FROUDE NO.	CAY NO.
○	.75	—	—
△	1.00	5.51	1.43
□	1.25	4.95	1.56

RE 3.0E+06 1000

LIFT COEFFICIENT - C_L



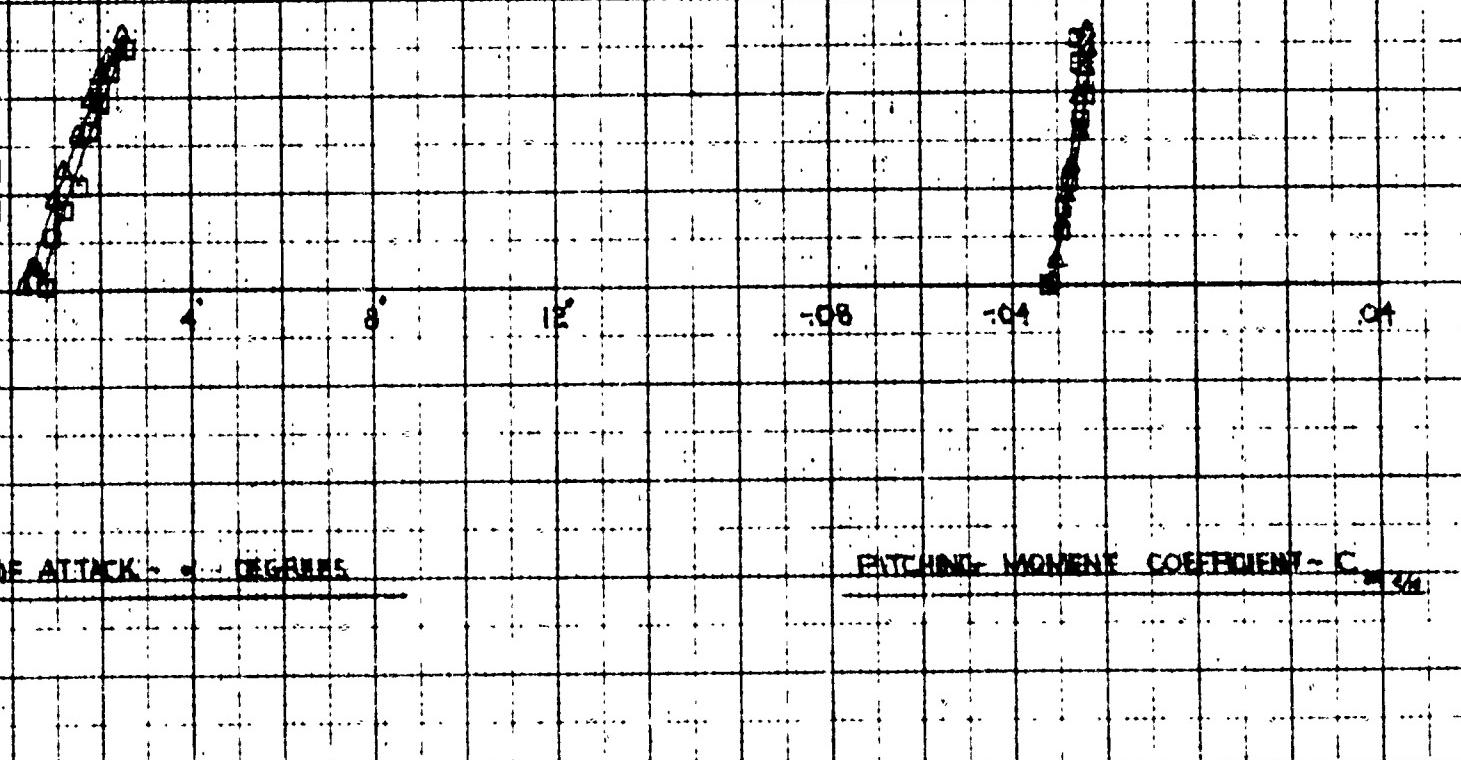
DRAG COEFFICIENT - C_D

ANGLE OF A

TEST NO 41
NO. 17
50.8.85 SQIN.
96 KTS

PAGE 1497

NOTE : SIC - 75 WAS NOT TESTED DUE TO EXTREME WATER
ROUGHNESS.



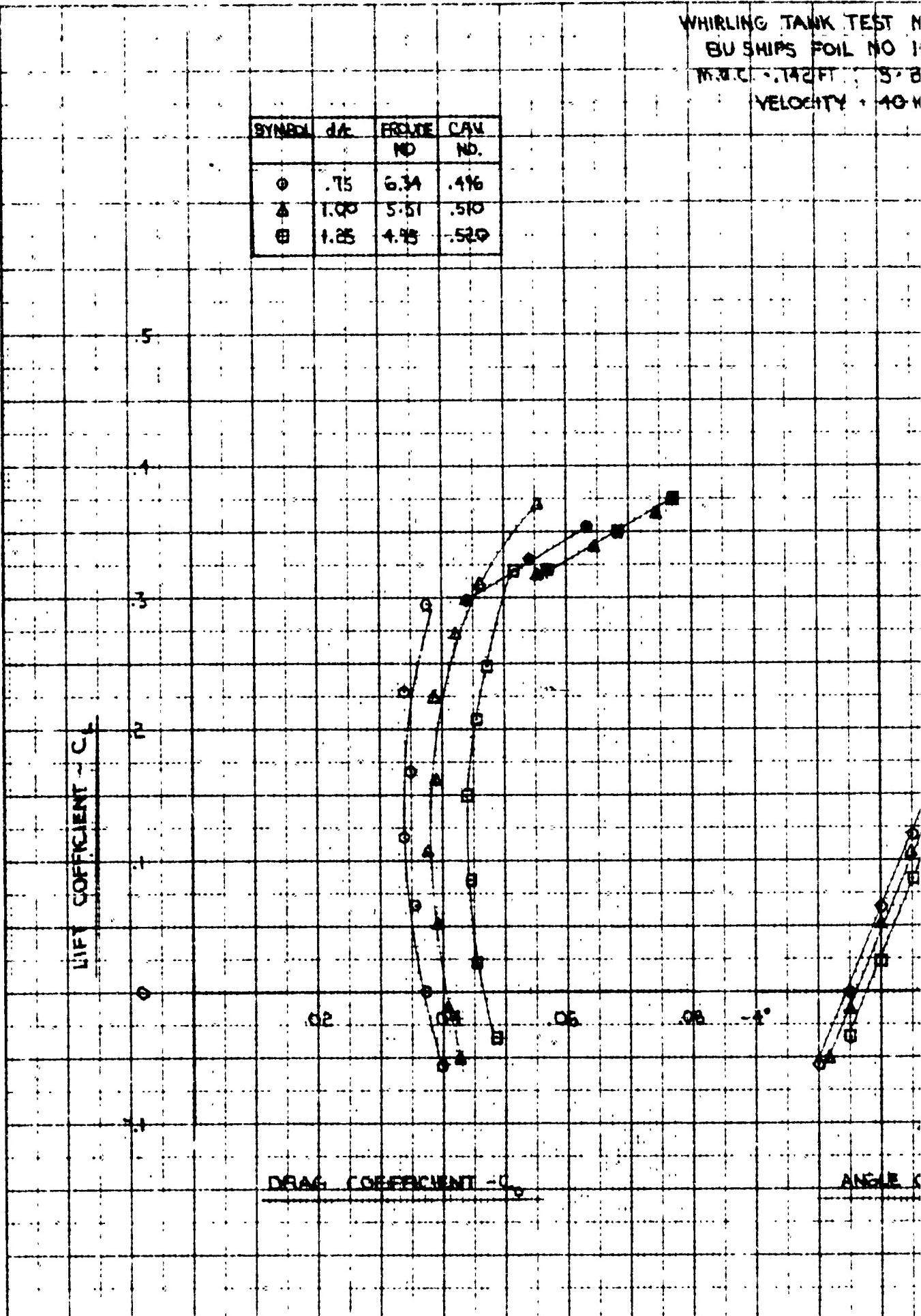
ANGLE OF ATTACK - DEGREES

PITCHING MOMENT COEFFICIENT - C_p

WHIRLING TANK TEST N
BU SHIPS FOIL NO 1
M.R.C. - 142 FT. S.B.
VELOCITY - 10 K

SYMBOL	dA	FRONDE CAN	NO.
○	.75	6.34	.416
●	1.00	5.51	.510
■	1.25	4.95	.520

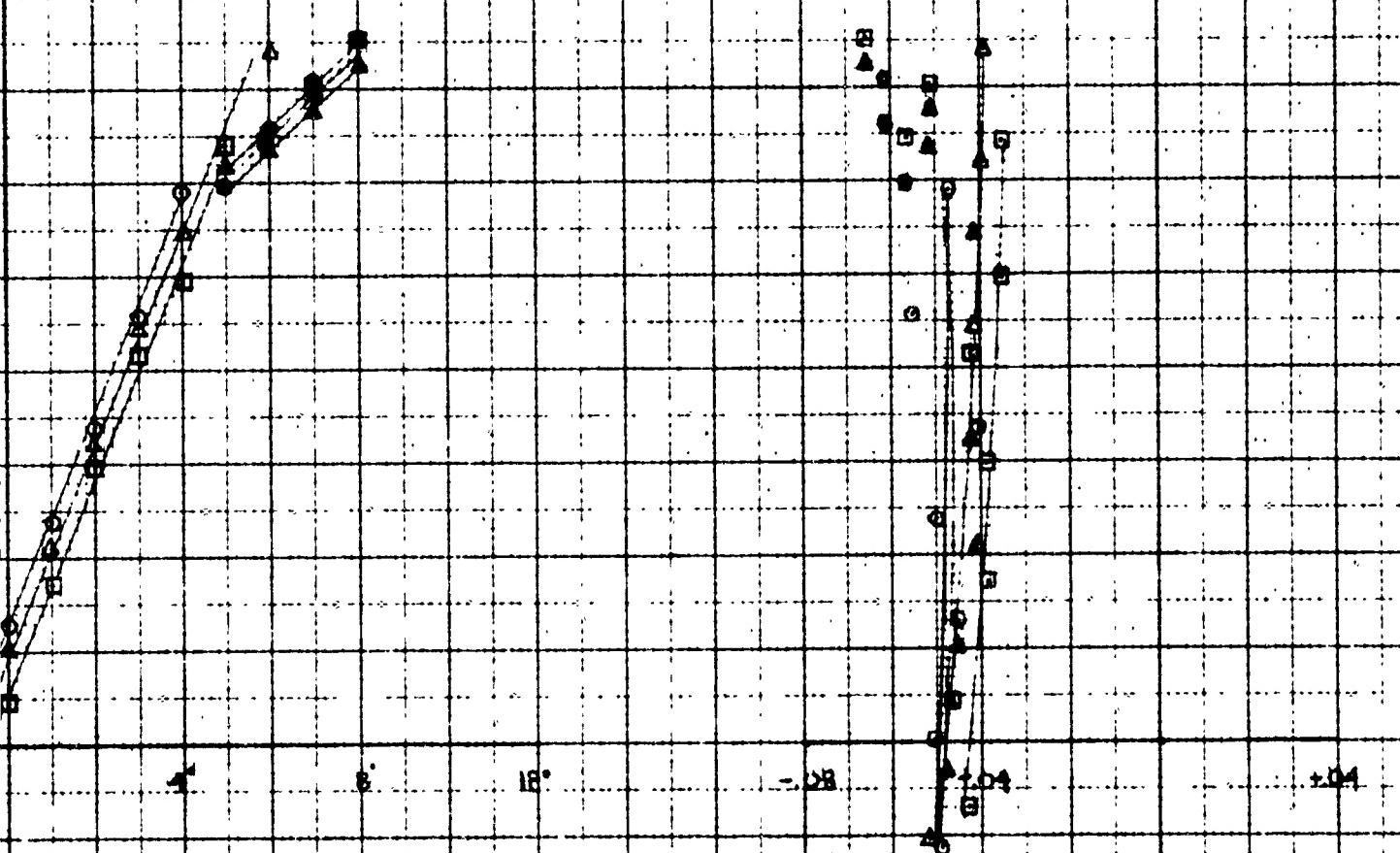
H.E. ALBANY 1967 5257



ST NO 48
10 18
3.835 SQ IN.
10 KTS.

PAGE IV.9B

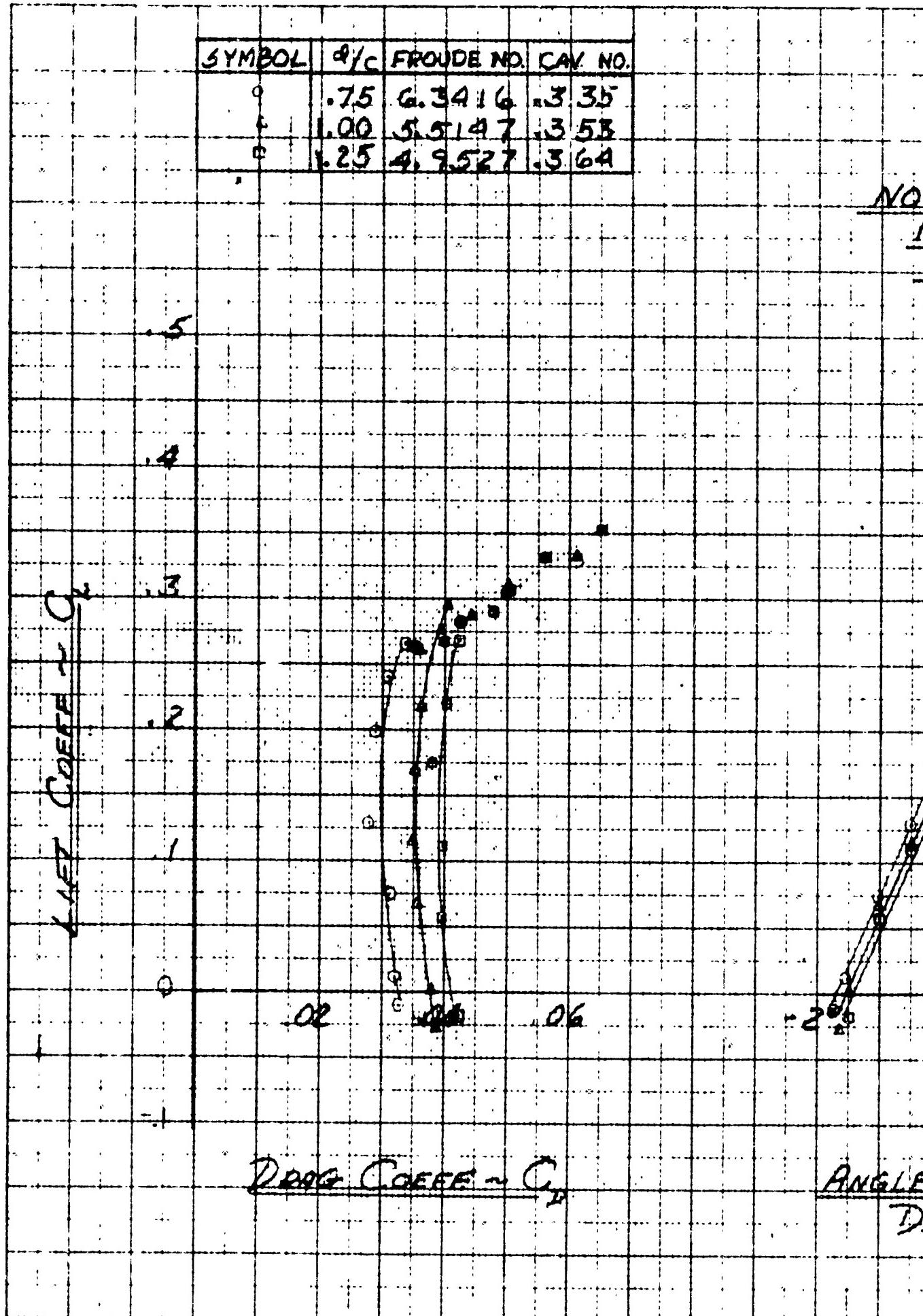
NOTE: DARKENED POINTS INDICATE VENTED FLOW



ANGLE OF ATTACK - α DEGREES

PITCHING MOMENT COEFFICIENT - C_M

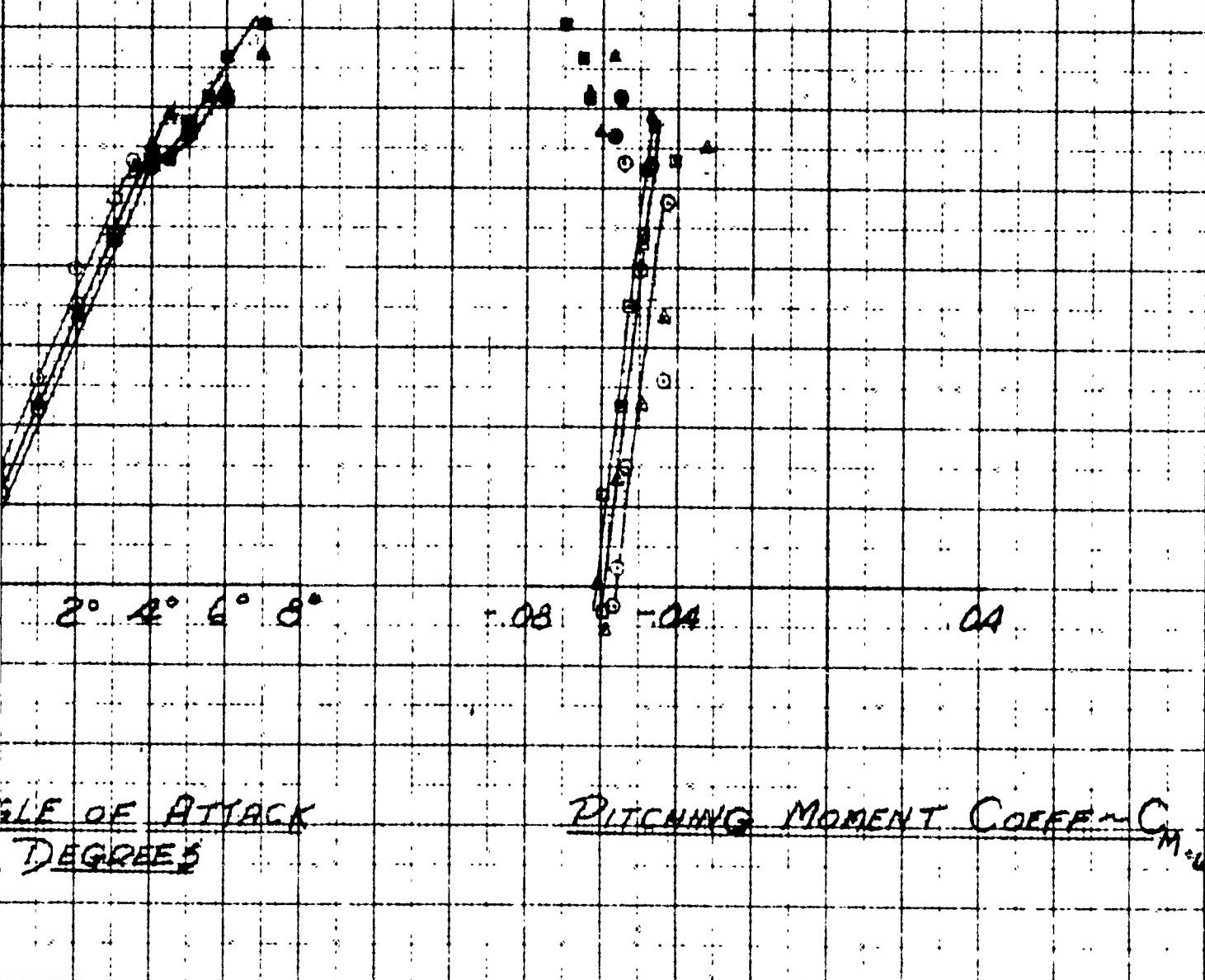
-5/4



W.T.T. NO. 4B BUSHING
N.A.G. = 102 FT. AREA = 0.230
V.E.L = 50 KTS.

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.

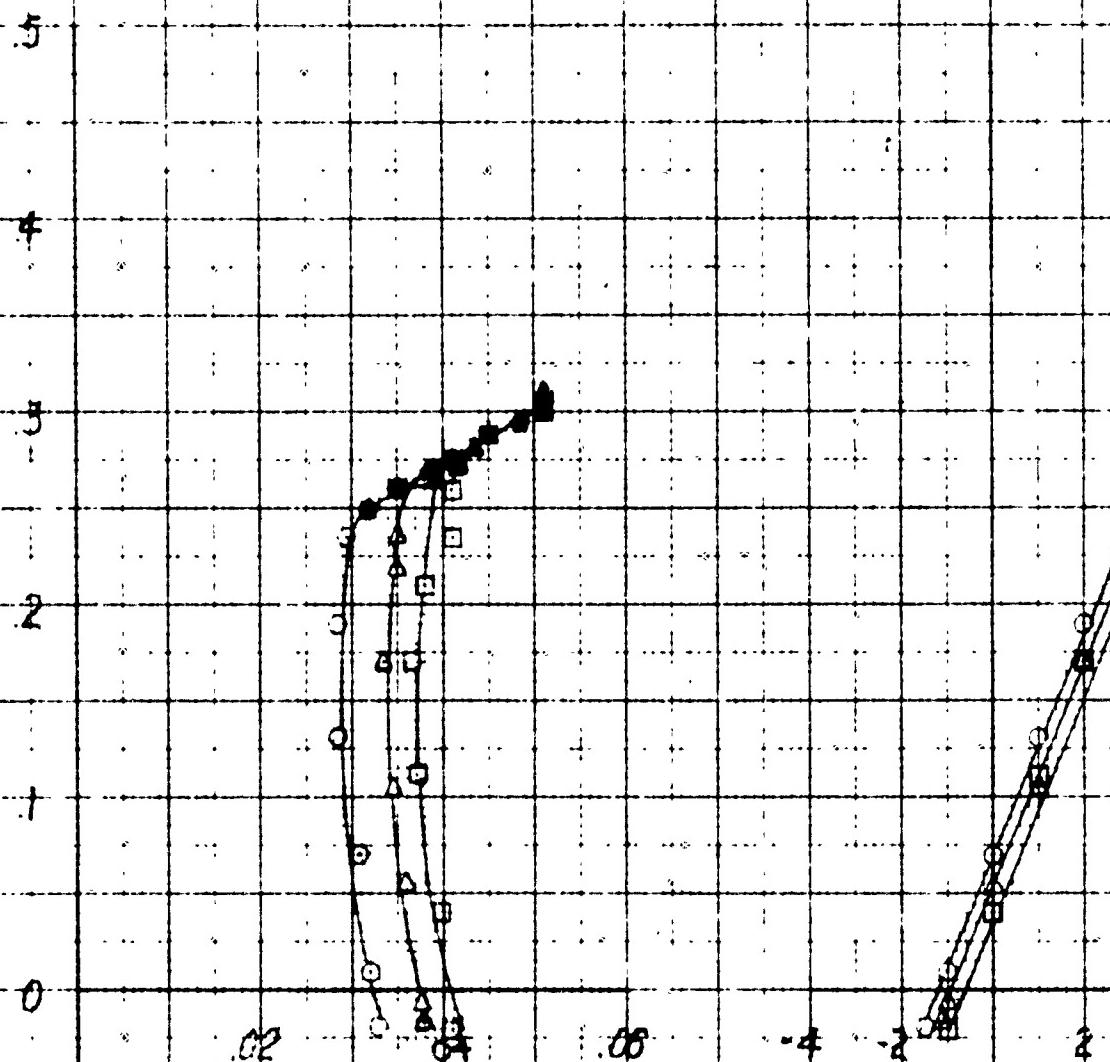


SYMBOL	D/C	FRONDE NO.	CAV. NO.
•	75	834	247
▲	100	551	262
■	125	495	279

NOTE

JET COEFFICIENT ~ C_j

M.E. 1000000000



DRAG COEFFICIENT ~ Cd

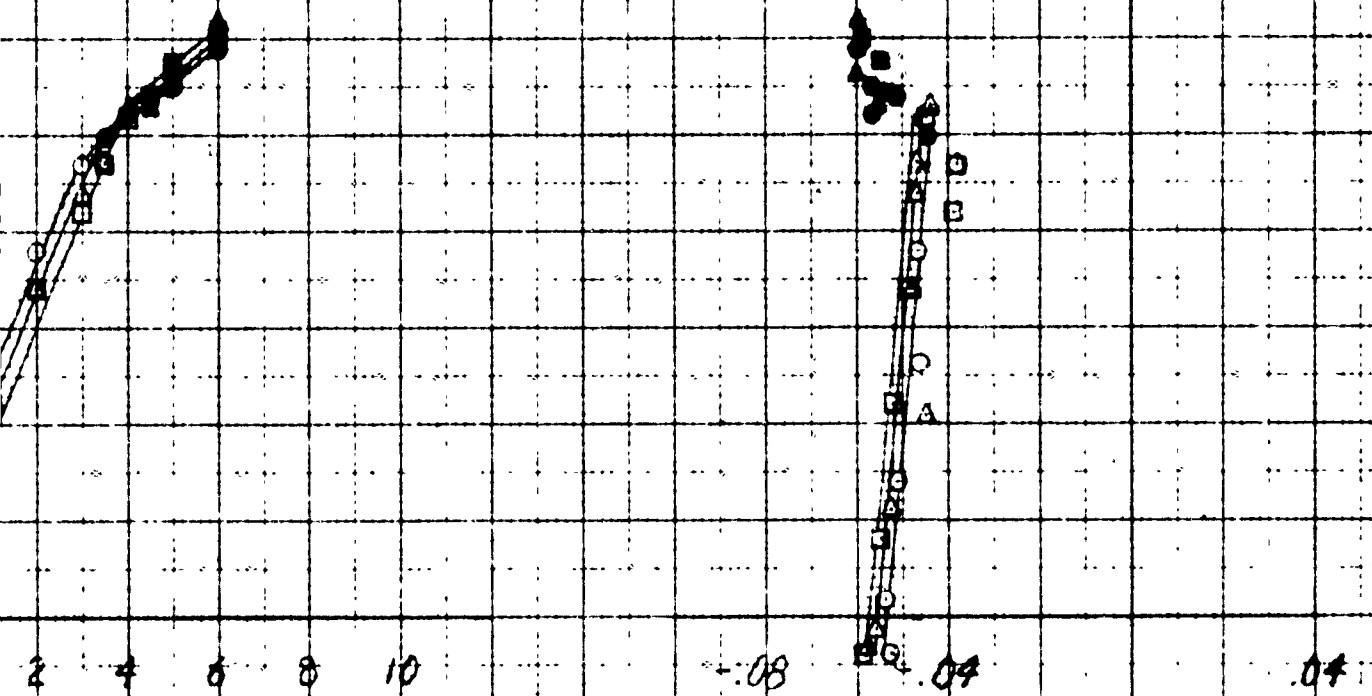
ANGLE

PAGE IV.100

WHIRLING TANK TEST NO. 48
BU. SHIPS FOIL. NO. 18
 $S = 8.23 \text{ IN}^2$ MAC = .192 FT.
 $V = 30 \text{ HTS.}$

NOTE:

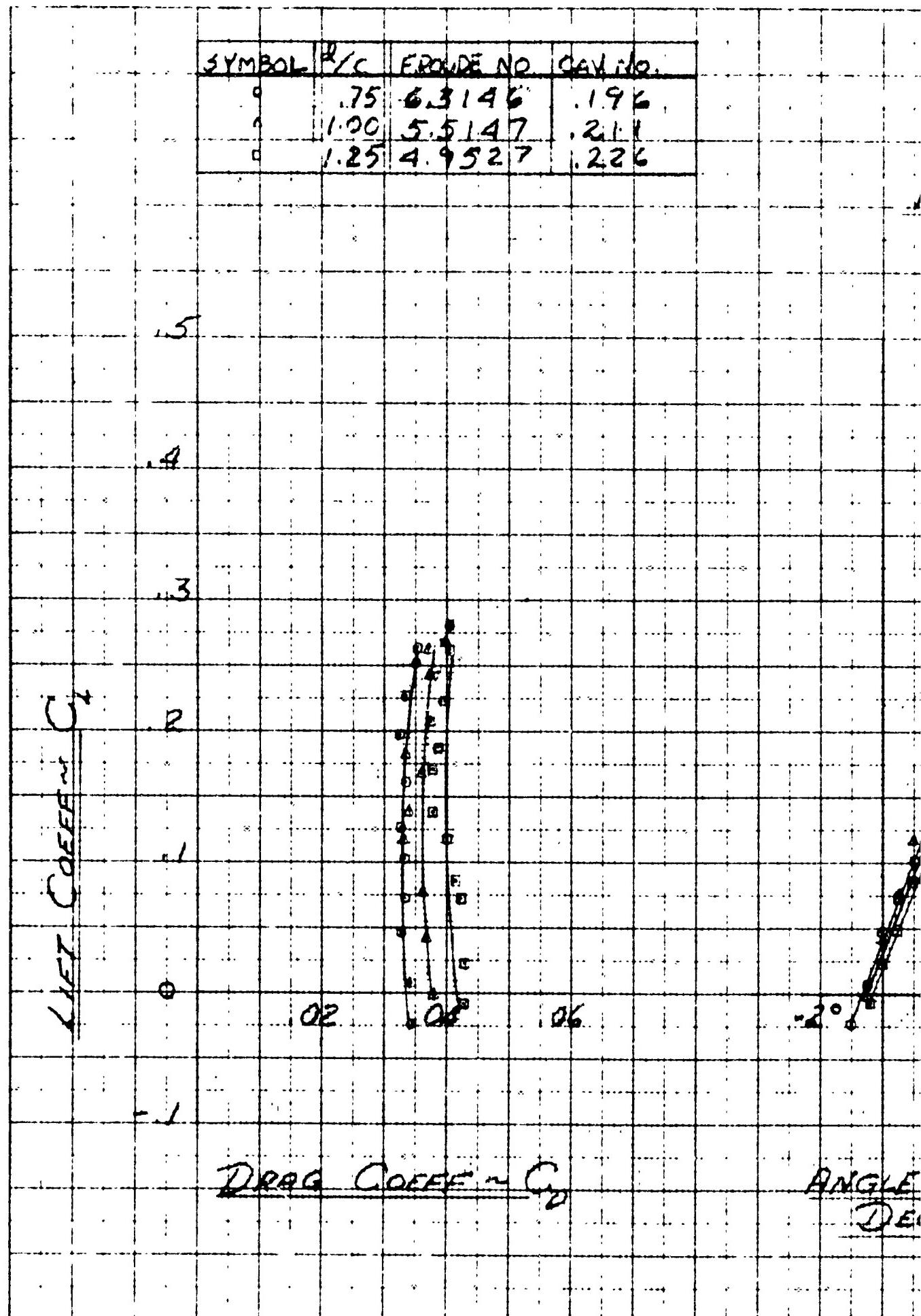
DARKENED POINTS INDICATE
VENTED FLOW.



ANGLE OF ATTACK ~ α - DEGREES

PITCHING MOMENT
COEFFICIENT ~ C_m

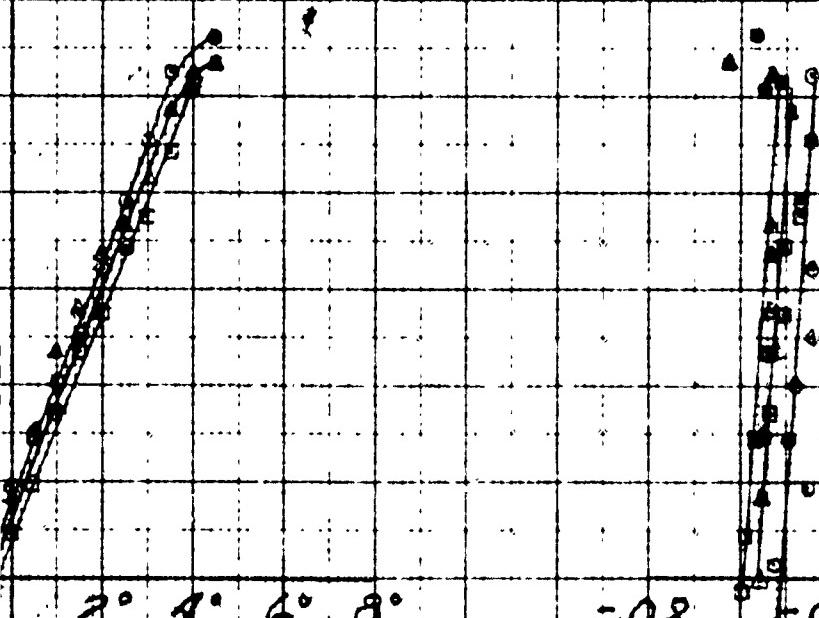
ME Number 1047 520



W.T.T. NO 48 BU SHIPS FOIL No. 18
 M.R.C. = .192 FT AREA = 8230⁴
 VEL = 70 KTS

NOTE:

1. DARKENED SYMBOLS
 INDICATE VENTED FLOW.



2° 4° 6° 8° -0.8 -0.4

LE OF ATTACK
DEGREES

PITCHING MOMENT
COEFF. ~ C_M

SYMBOL	%	FREQUENCY NO	CAR. NO.
o	.75	6.3416	.158
o	1.00	5.5147	.175
o	1.25	4.9527	.192

NOTE:

118

14

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11

Liver Cancer

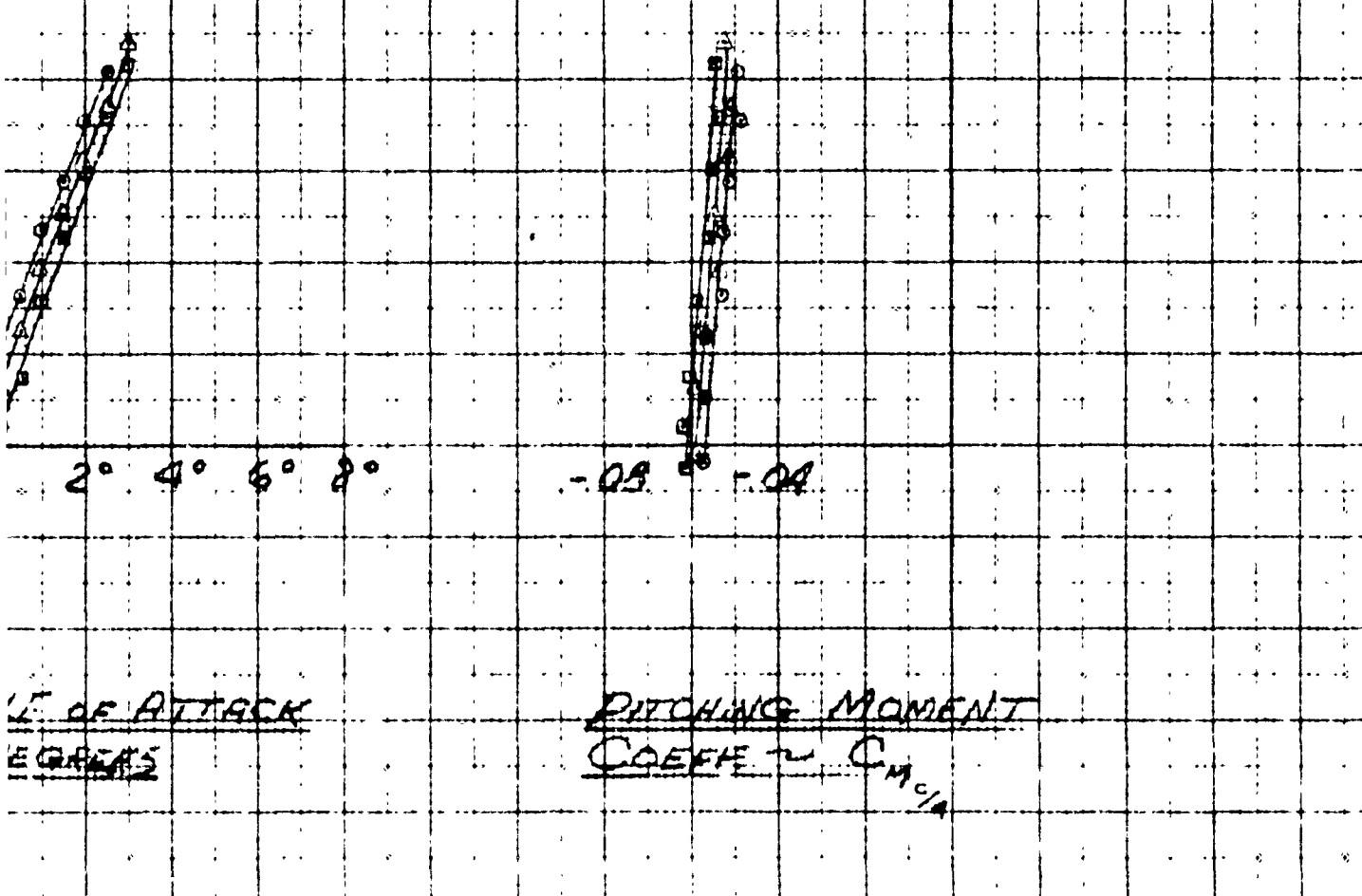
Deg CREEF - C

~~ANGLE~~
~~DEG~~

PAGE IV. 02

W.T.T. 110.48 Buskirk Foil No. 13
M.A.C. = 1.92 FT AREA = 8.23 ft^2
VEL. = 80 KTS.

DARKENED SYMBOLS
INDICATE VENTED FLOW.



WHIRLING TANK TEST
BU SHIPS FOIL NO
M.A.C. 142 FT S.
VELOCITY 30 KT

SYMBOL	CLF	PROUDIE CAV	
		NO	NO
○	.75	6.34	.186
★	1.00	5.81	.183
■	1.25	4.75	.169

K-E COEFFICIENT - C_E

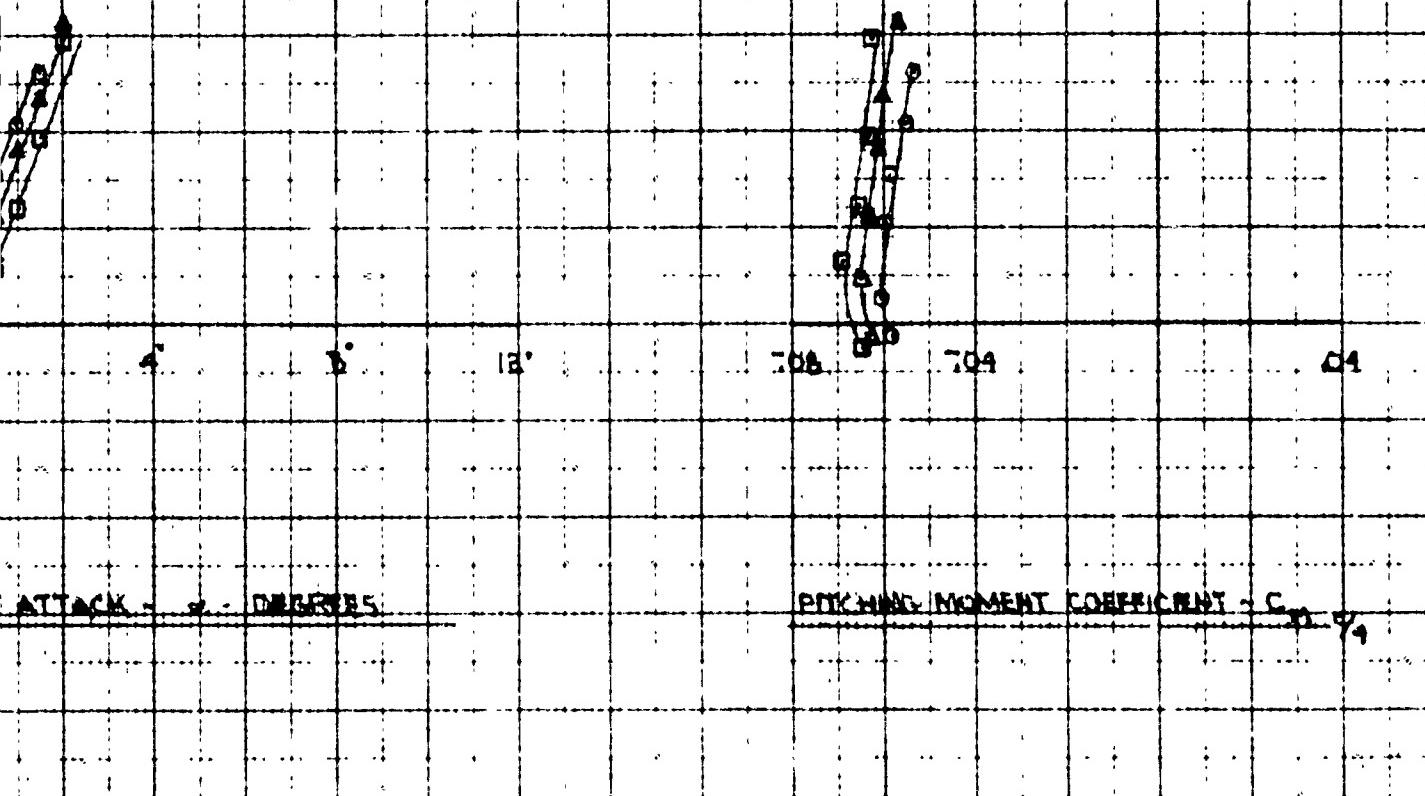
LIFT COEFFICIENT - C_L

DRAG COEFFICIENT - C_D

ANGLE OF ATT.

EST NO 48
NO 18
5.83 SQ IN
10 KTS

PAGE IV. 103



SYMBOL	d/c	FROUDE NO	CAV. NO
--------	-------	-----------	---------

○	75	6.34	.130
△	100	5.51	.144
□	125	4.95	.159

5

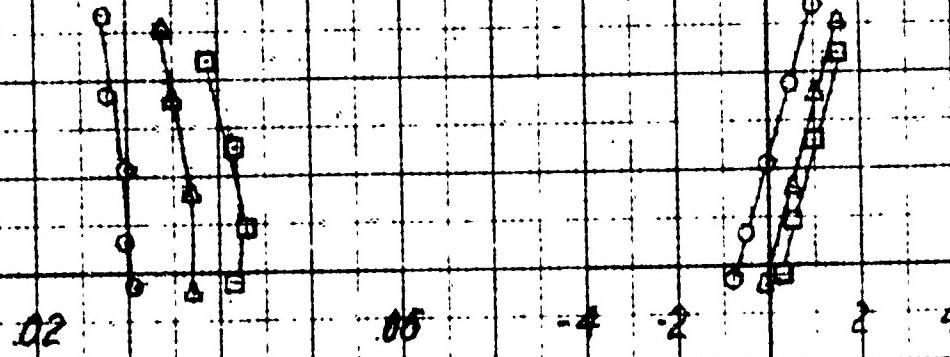
4

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2

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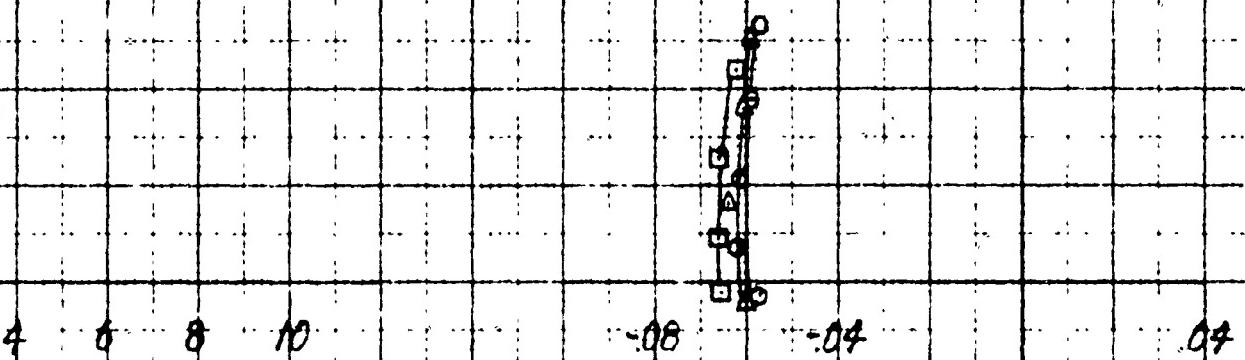
JET COEFFICIENT ~ C_J JET COEFFICIENT ~ C_J

+

DRAG COEFFICIENT ~ C_D ANGLE α

PAGE IV.104

WHIRLING TANK TEST NO. 48
BU SHIPS FOIL NO 18
 $S = 8.23 \text{ m}^2$, $\text{MAC} = 14.2 \text{ EI}$
 $V = 35 \text{ KTS.}$



4 6 8 10

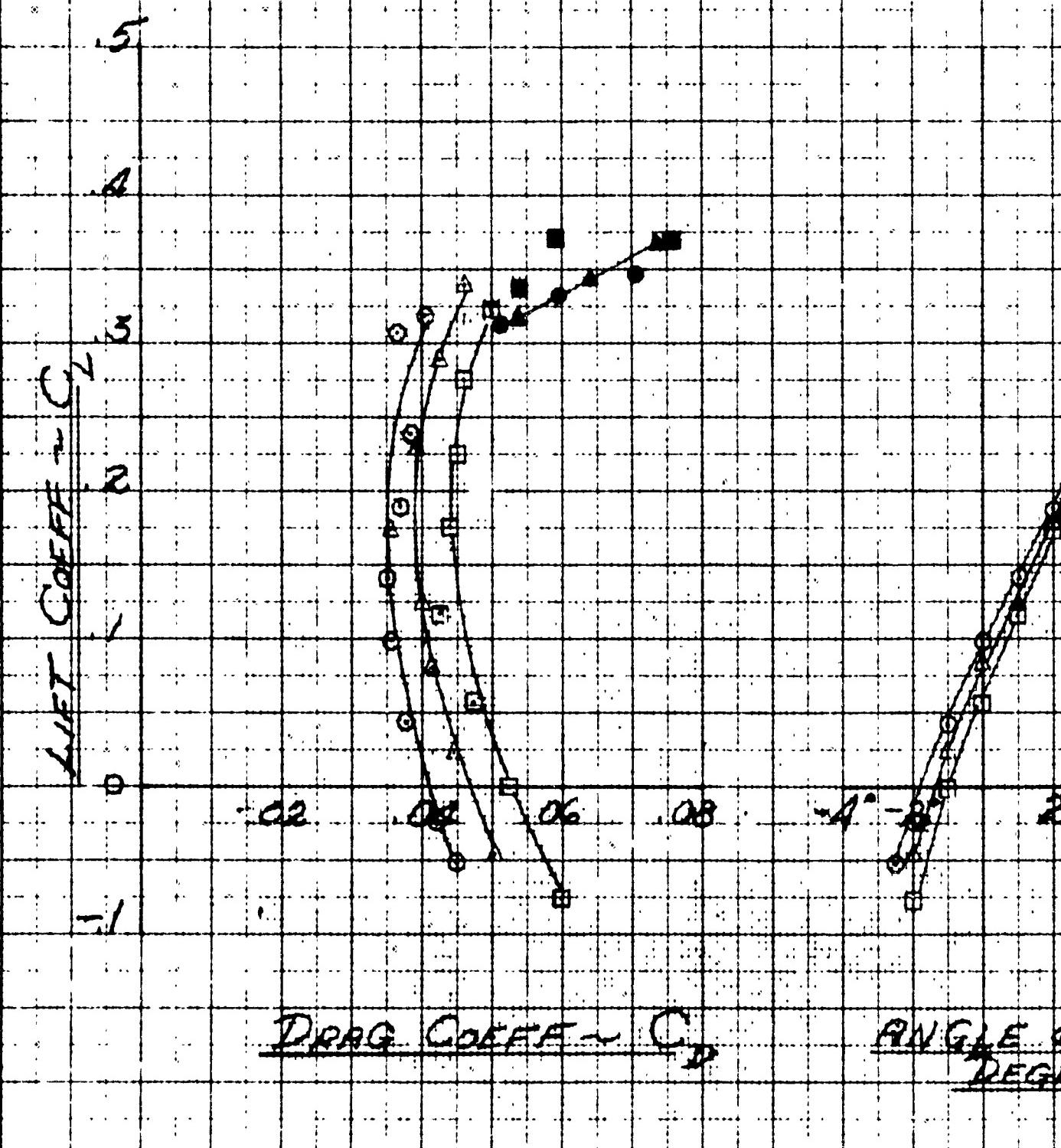
-08 -04 04

ANGLE OF ATTACK - DEGREES

PITCHING MOMENT
COEFFICIENT = C_M

SYMBOL	$\% C$	FROUDE NO.	CAY No.
--------	--------	------------	---------

O	.75	7.1767	4.82
Δ	1.00	6.2353	4.93
□	1.25	5.5949	5.10

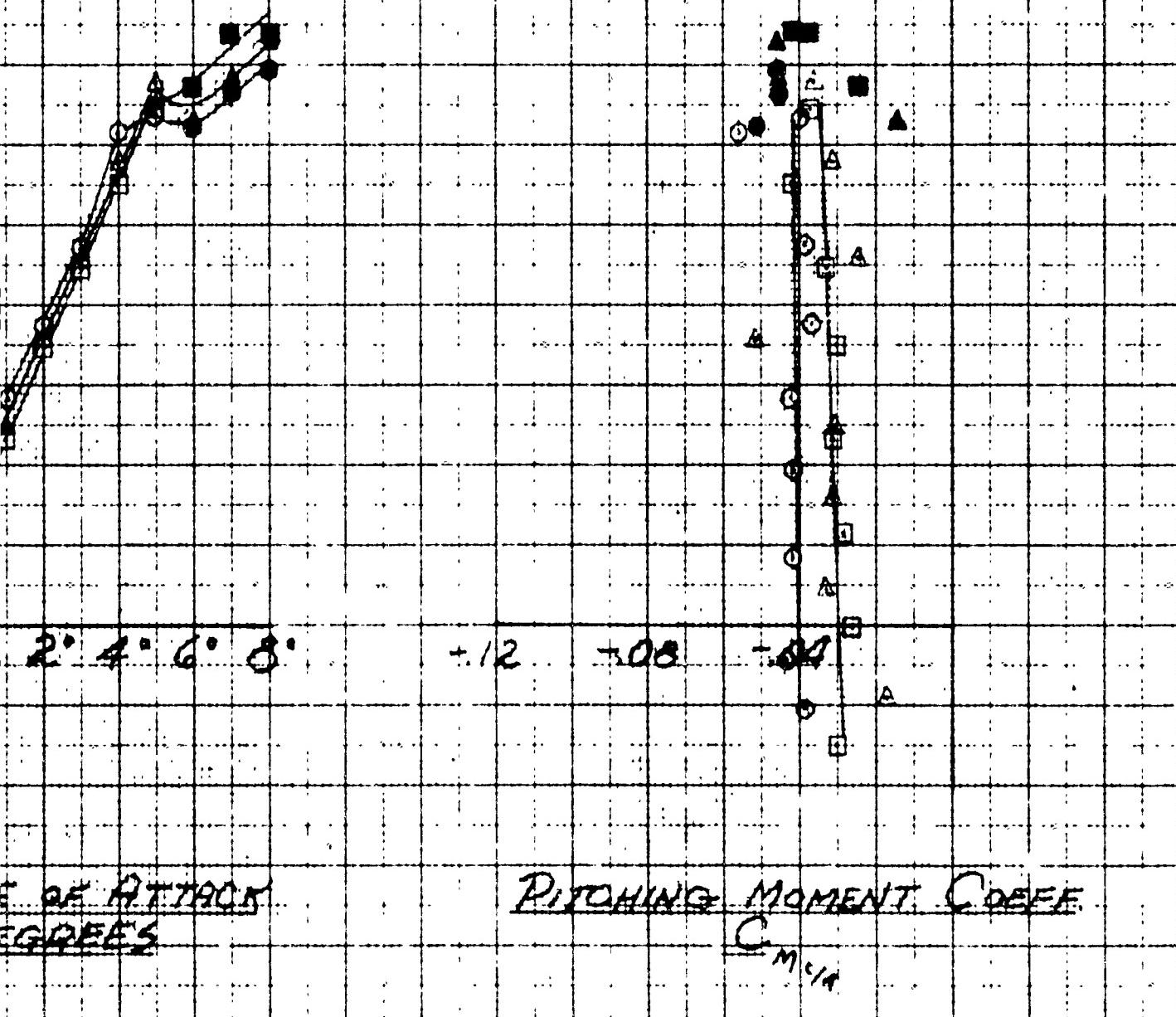


PAGE IV.105

M.U.T. NO. 49 PUSHING FOIL NO. 19
M.A.C. = .11 FT. AREA = 4.94 FT²
V_EC = 40 KTS.

NOTE:

1 DARKENED SYMBOLS
INDICATE VENTED FLOW.



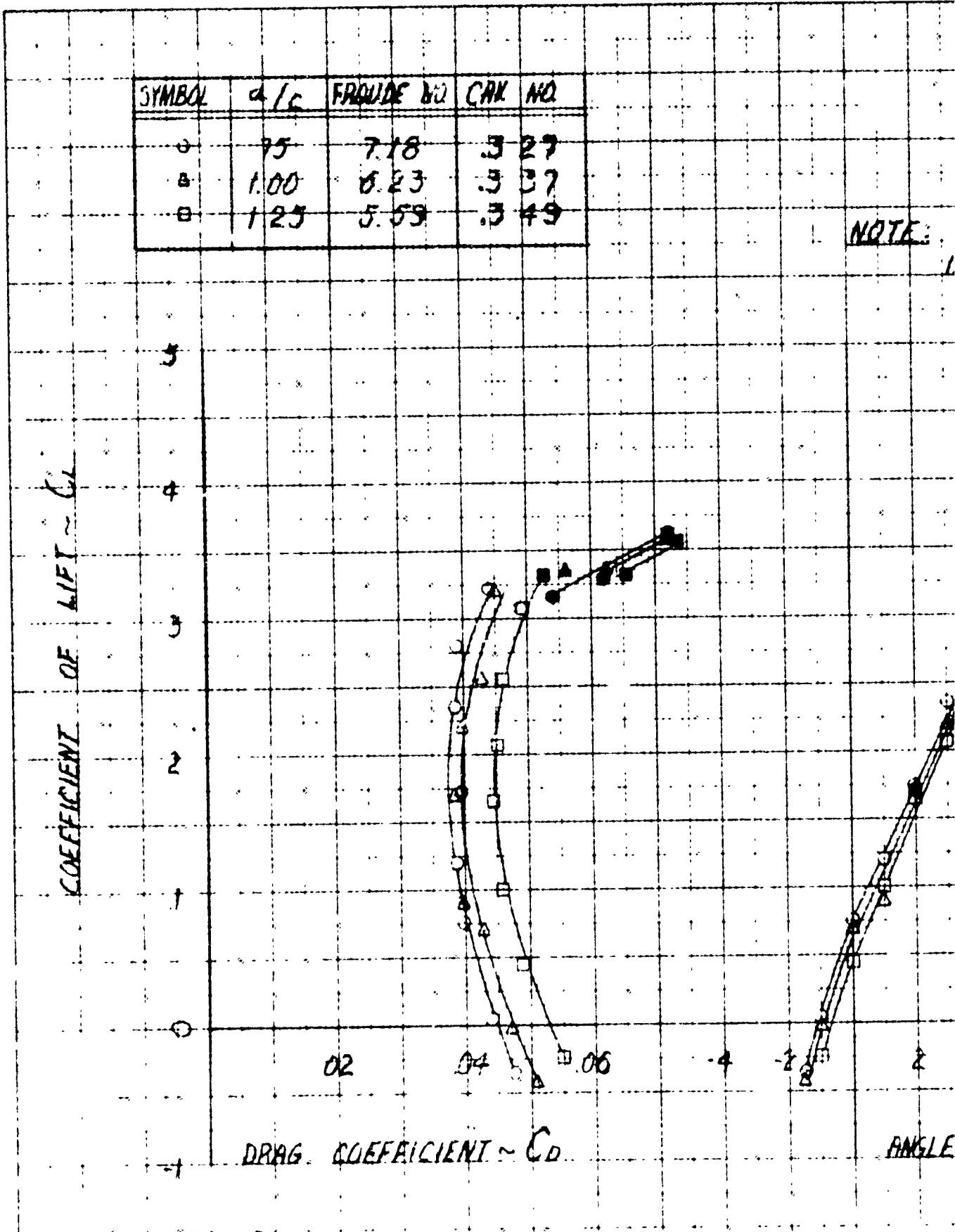
SYMBOL	a/c	FROUDE NO	CAN NO
0	.75	7.18	3 27
0	1.00	8.23	3 37
0	1.25	5.59	3 49

NOTE:

COEFFICIENT OF LIFT ~ C_L

DRAG COEFFICIENT ~ C_D

ANGLE



PAGE 14106

WHIRLING TANK TEST NO. 49

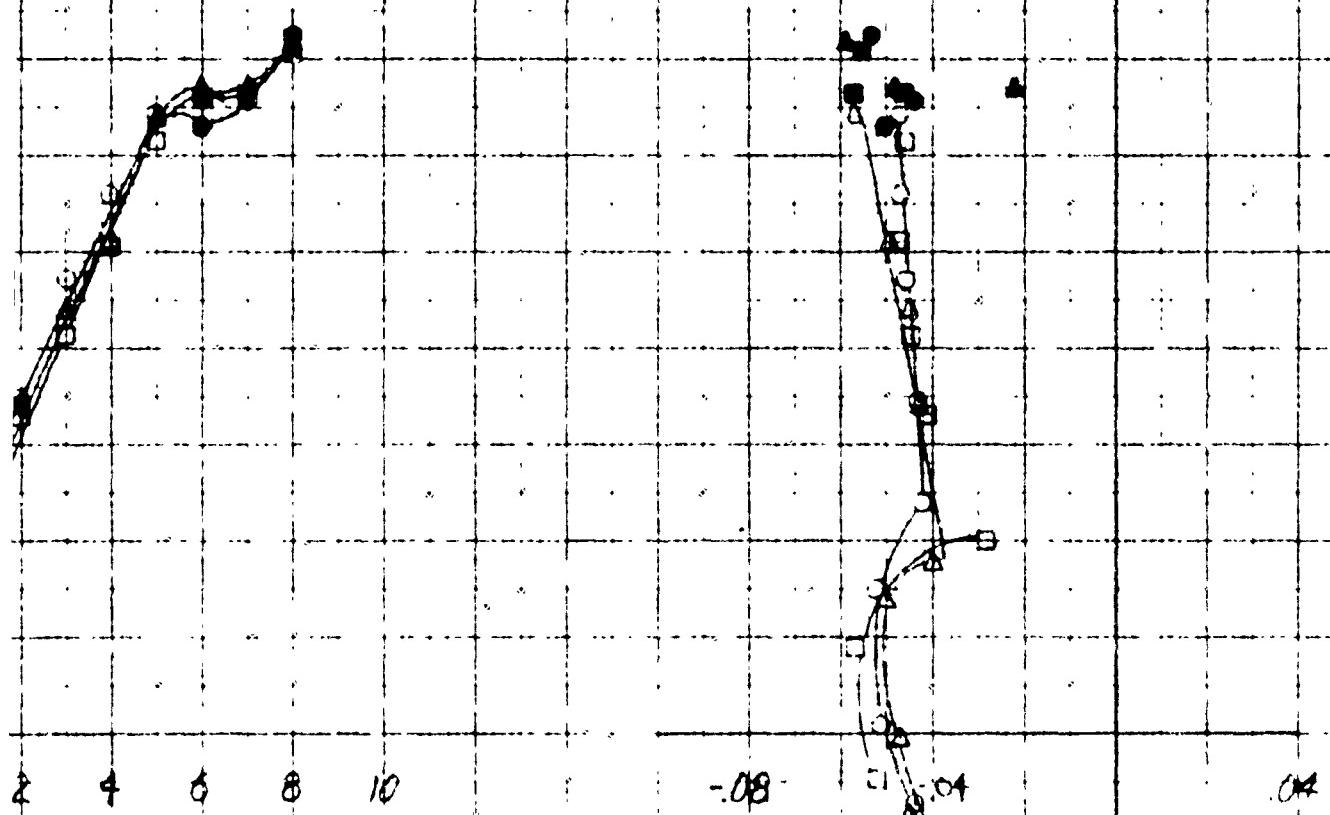
BU. SHIPS FOIL NO. 19

$S = 4.94 \text{ IN}^2$, $\text{MAC} = 1.0 \text{ FEET}$

$V = 56 \text{ MTS.}$

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.

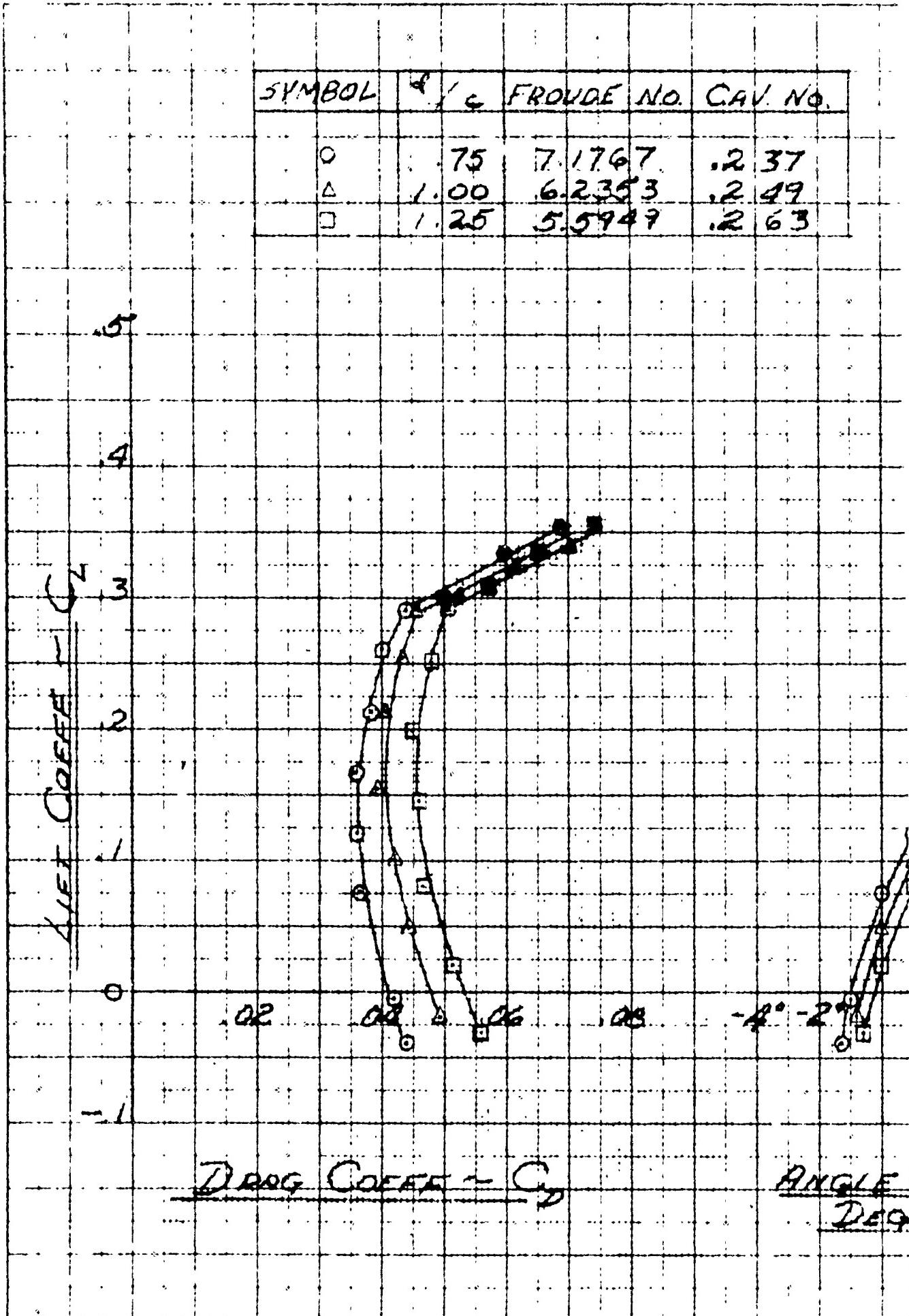
See Figure 38X



ANGLE OF ATTACK - α - DEGREES.

PITCHING MOMENT

COEFFICIENT - C_m

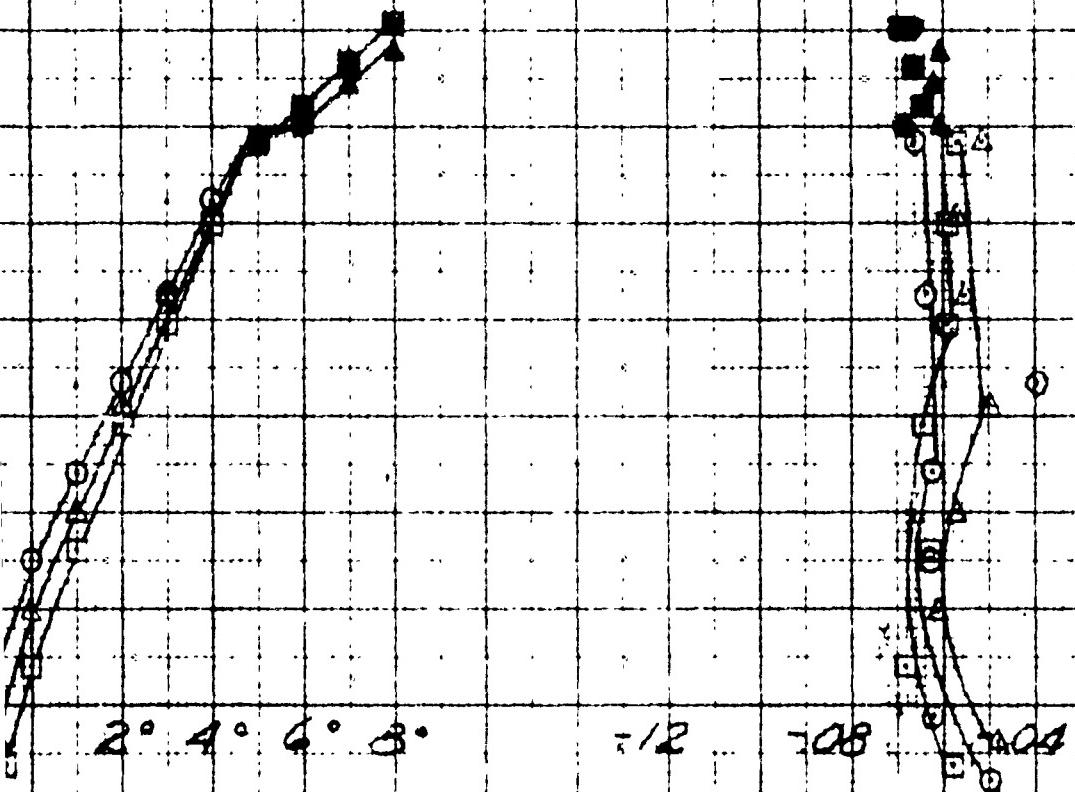


PAGE 14.107

W.T.I. NO. 49 BUSCHIPS EOL NO. 19
MAC = .11 FT. AREA = 4.94 FT²
VEL = 60 KTS

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW



-12 -08 -04

2 DEG ATTACK
DEGREES

PITOT MOMENT: CREEF

C_M
C_G

SYMBOL	a/c	FROUDE NO.	CAV. NO.
O	.75	7.18	.185
A	1.00	8.23	.197
B	1.25	5.59	.209

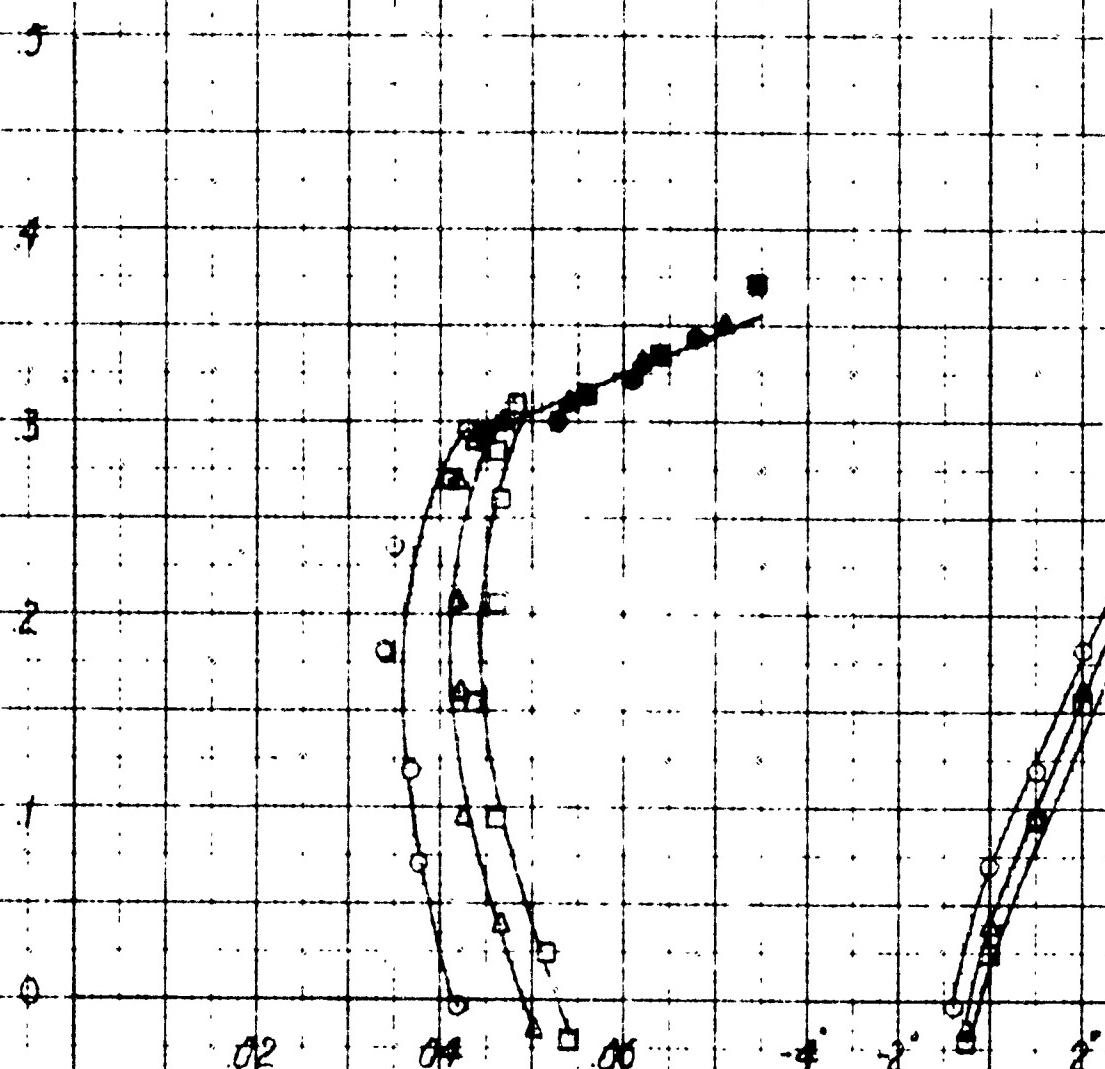
NOTE:

COEFFICIENT OF LIFT ~ C_L

K.E. WIND TUNNEL

DRAG COEFFICIENT ~ C_D

ANGLE



PAGE IV.105

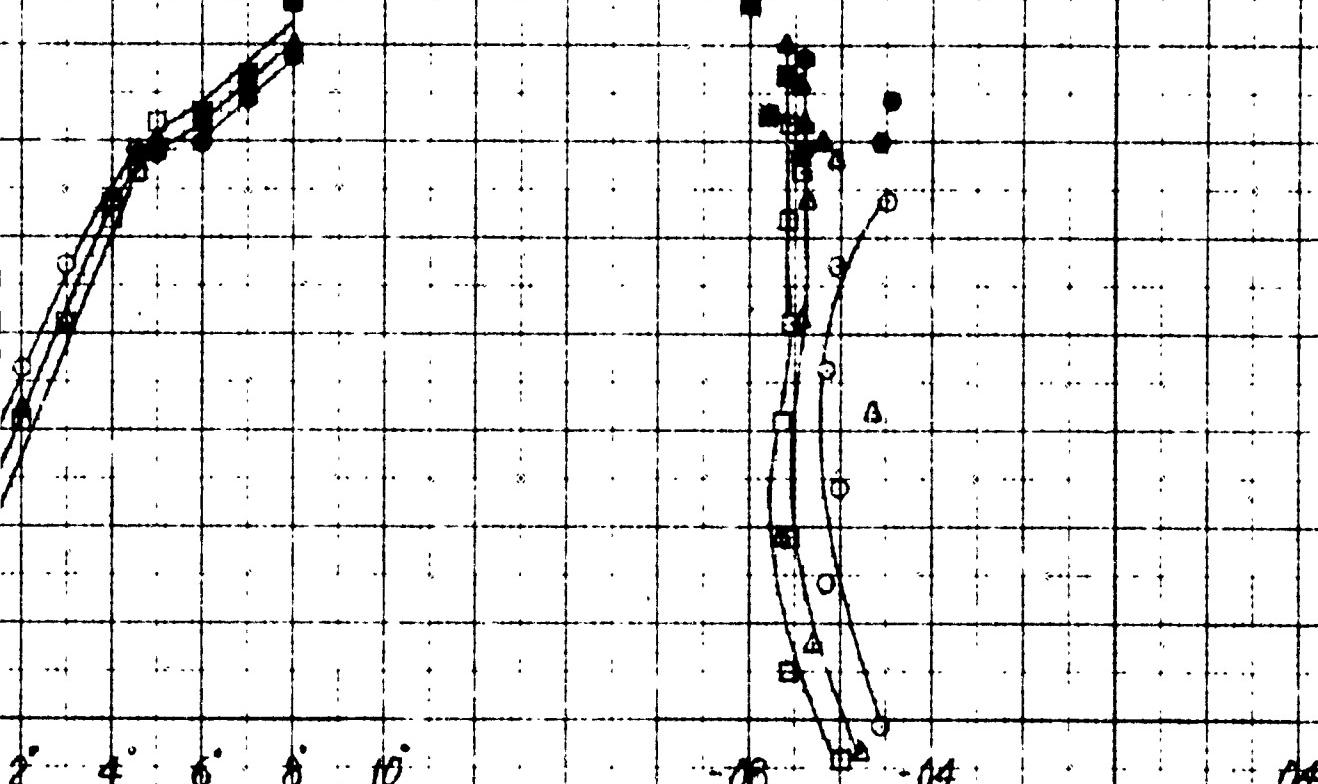
WHIRLING TANK TEST NO. 49

BU SHIPS FOIL NO 19

$S = 4.94 \text{ IN}^2$; $MAC = .110 \text{ ET}$

$V = 70 \text{ HTS}$

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.



ANGLE OF ATTACK ~ DEGREES PITCHING MOMENT
COEFFICIENT ~ $\text{CM}_{1/4}$

SYMBOL	D/C	GROUP NO.	CAR. NO.
O	.75	71767	.150
A	1.00	62353	.162
C	1.25	55949	.175

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Elect Coffee - C

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.02 .00 .06 .08

-20 0 20

200g COFFEE in C

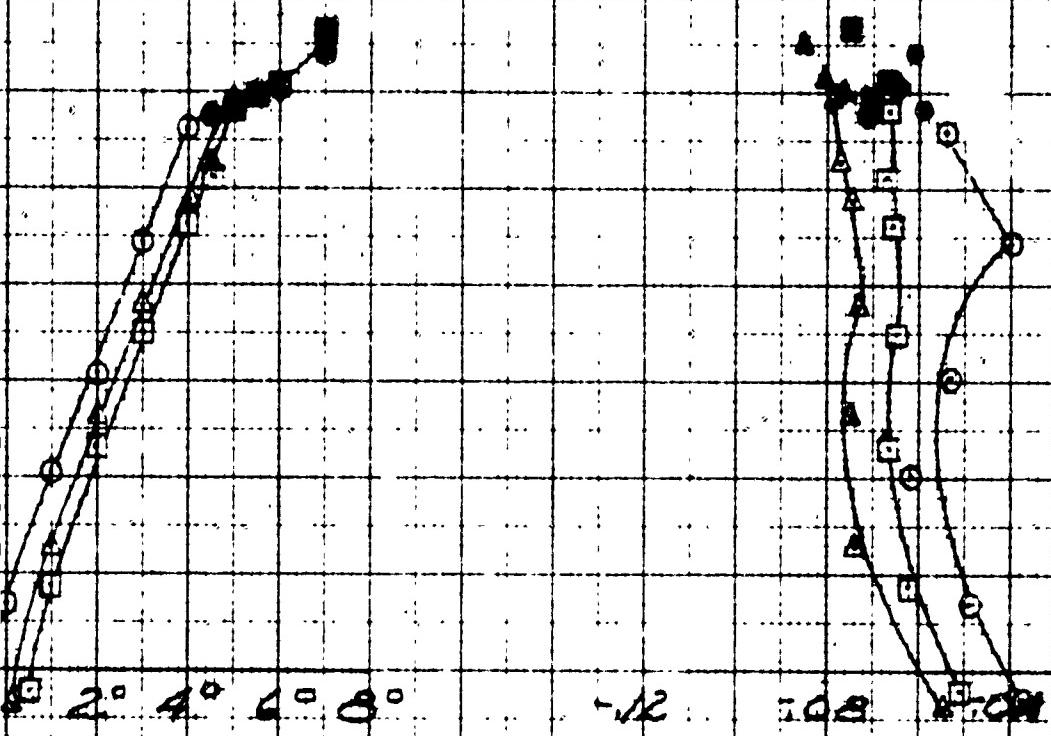
ANGLE
20

PAGE IV.109

W.T.I. NO 49 BUSHIPS NO. 19
N.A.G. = 11FT. AREA = 4.940"
VEL = 80 KTS.

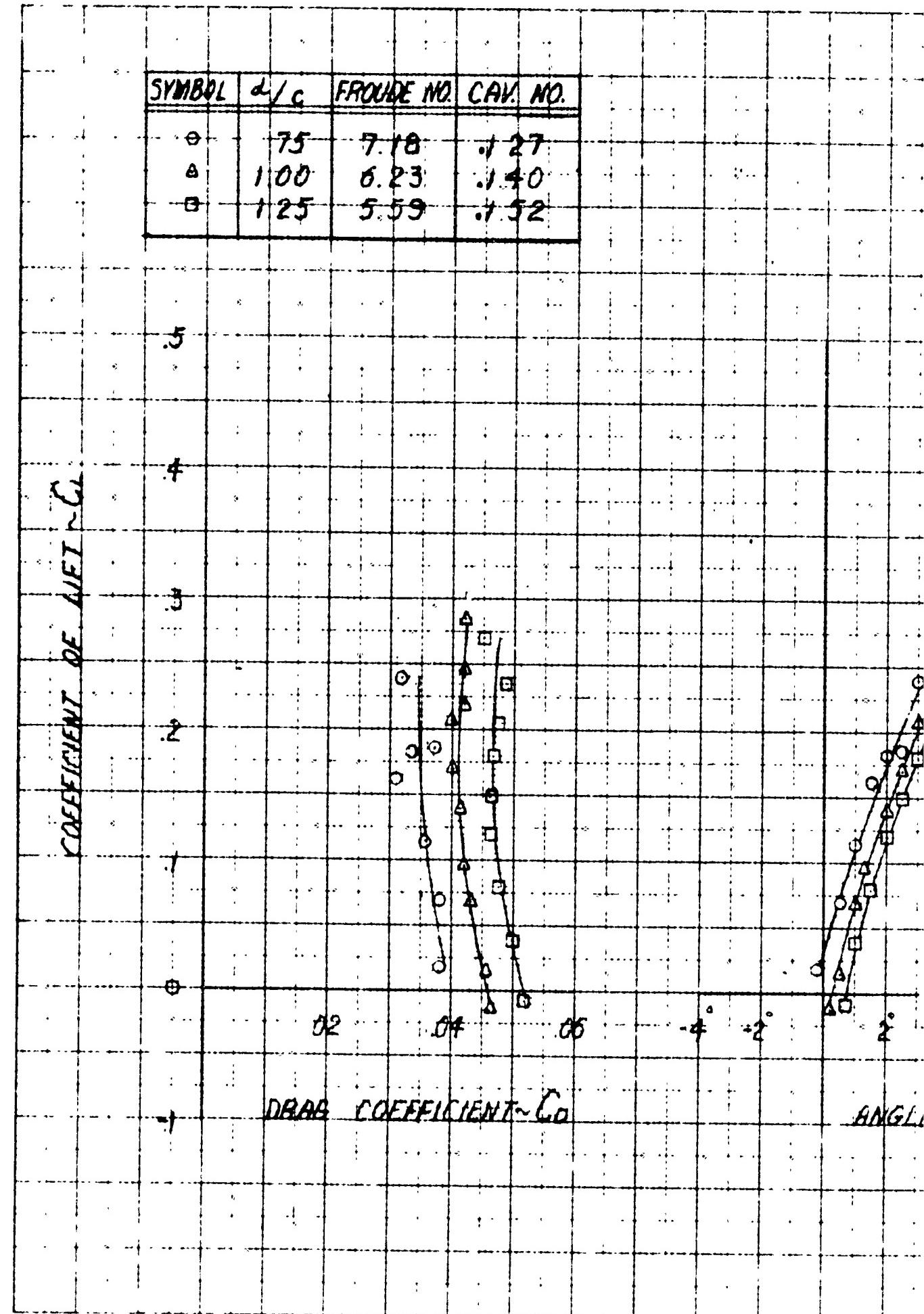
NOTE:

1 DARKENED SYMBOLS
INDICATE VENTED FLOW



LE DE ATTACK
DEGREES

PIROWING moment COEFF.
 C_m



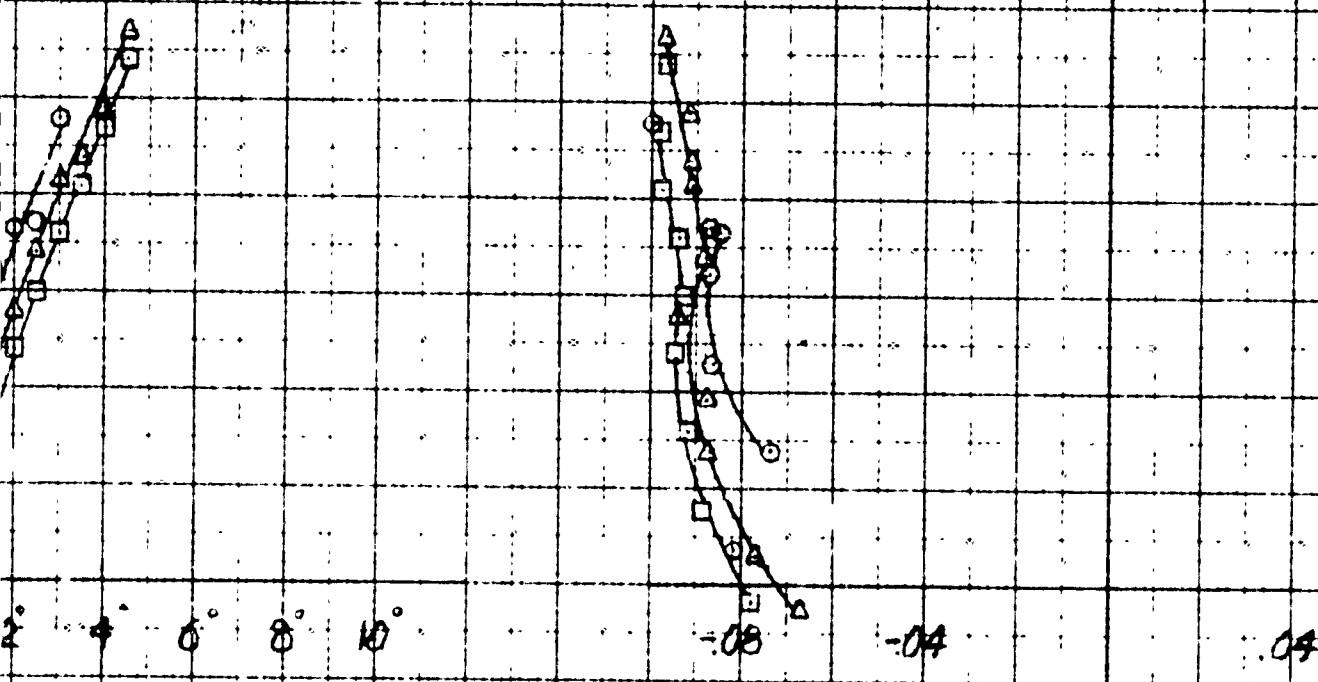
PAGE IV. NO

WHIRLING TANK TEST NO. 49

BU SHIPS FOIL NO 19

S = 4.94 IN²; MAC = .110 FT

V = 90 MTS.



ANGLE OF ATTACK - α - DEGREES

PITCHING MOMENT
COEFFICIENT - C_m

SYMBOL	R/C	FRONDE No.	CAV. No
○	75		
△	1.00	62353	.122
□	1.25	55999	.135

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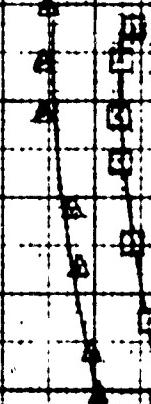
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Lett. Codex 2



102

三

10

10

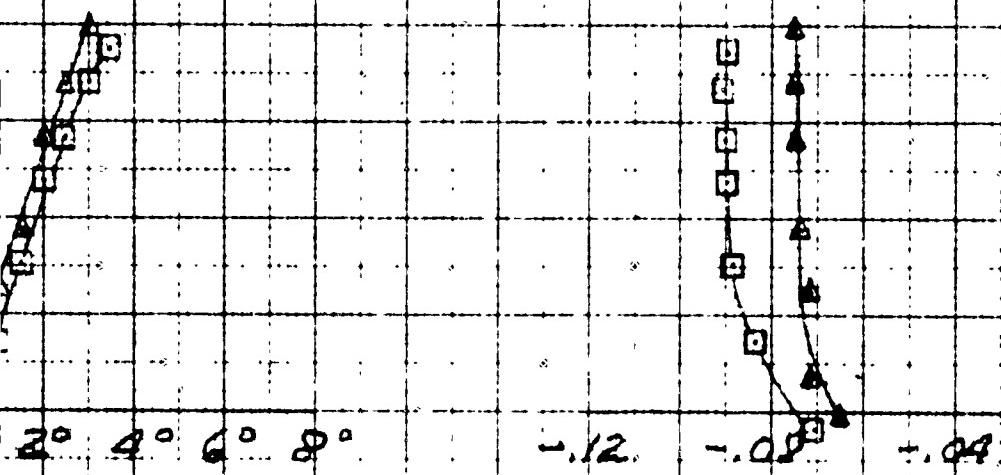
二

Doug Coffey

Angle

PAGE IV. III.

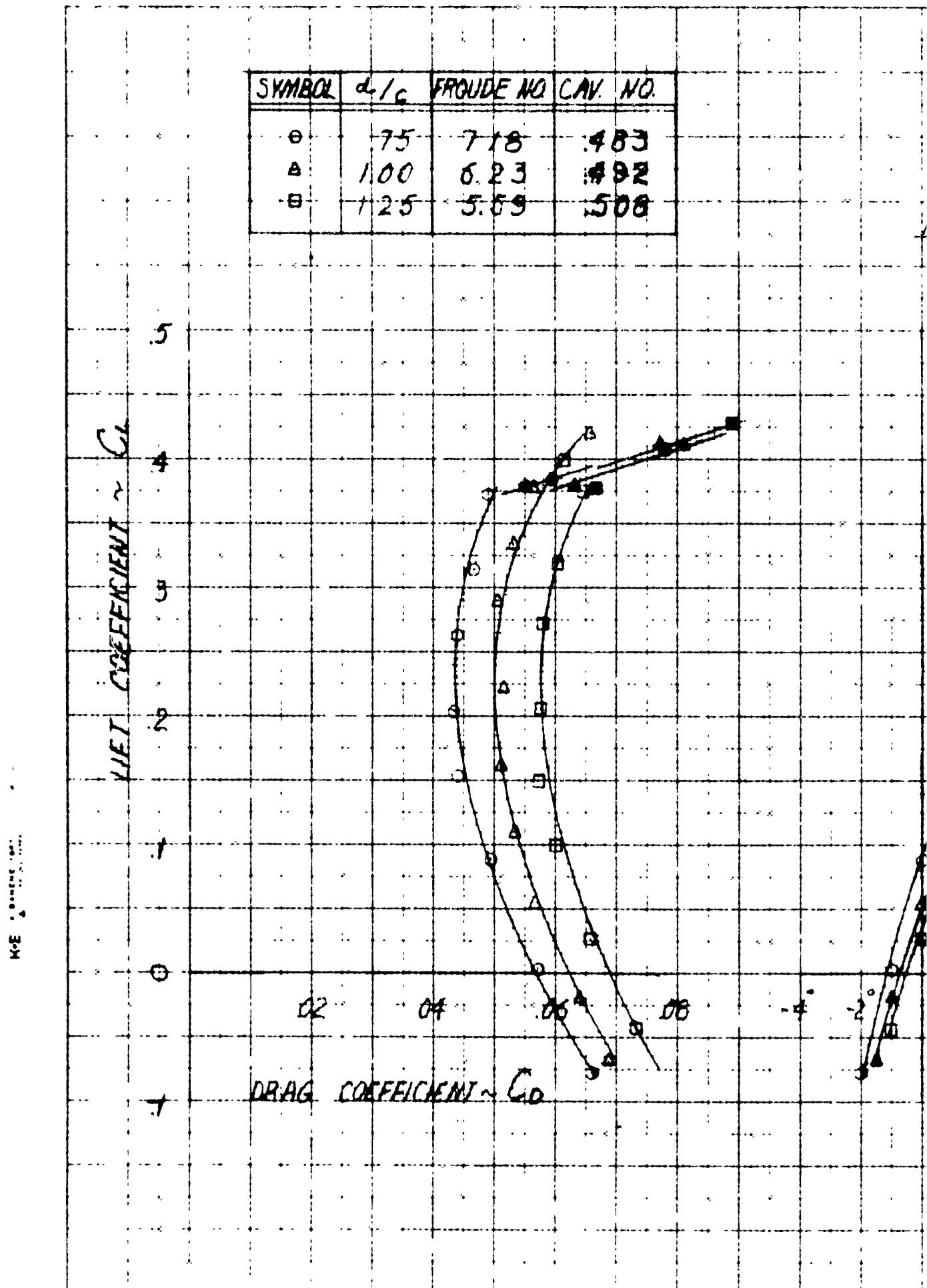
WIT. NO 49. BUSHIPS FOIL NO 19
MAC = 11 FT AREA = 4.98 FT²
VEL = 96 KTS



ANGLE OF ATTACK
DEGREES

PITCHING MOMENT COEFF
CM

SYMBOL	d/l _c	FROUDE NO	CAV. NO.
θ	75	7.18	483
Δ	100	6.23	492
□	125	5.59	508



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WHIRLING TANK TEST NO. 50

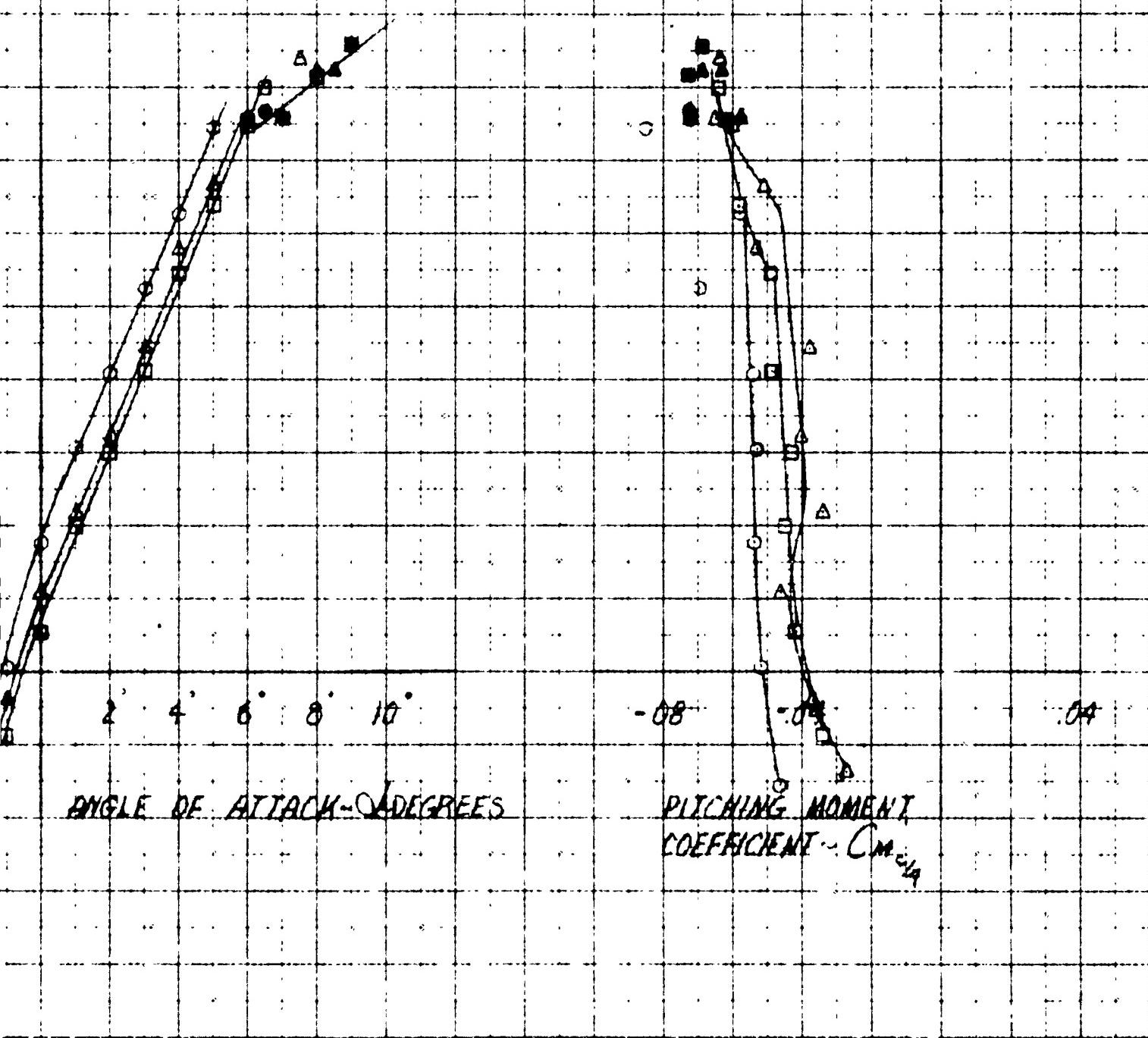
BY SHIPS FOIL NO. 20

$AAC = 110 \text{ FT.}^2$; $S = 4.94 \text{ IN}^2$

$V = 40 \text{ MTS.}$

NOTE:

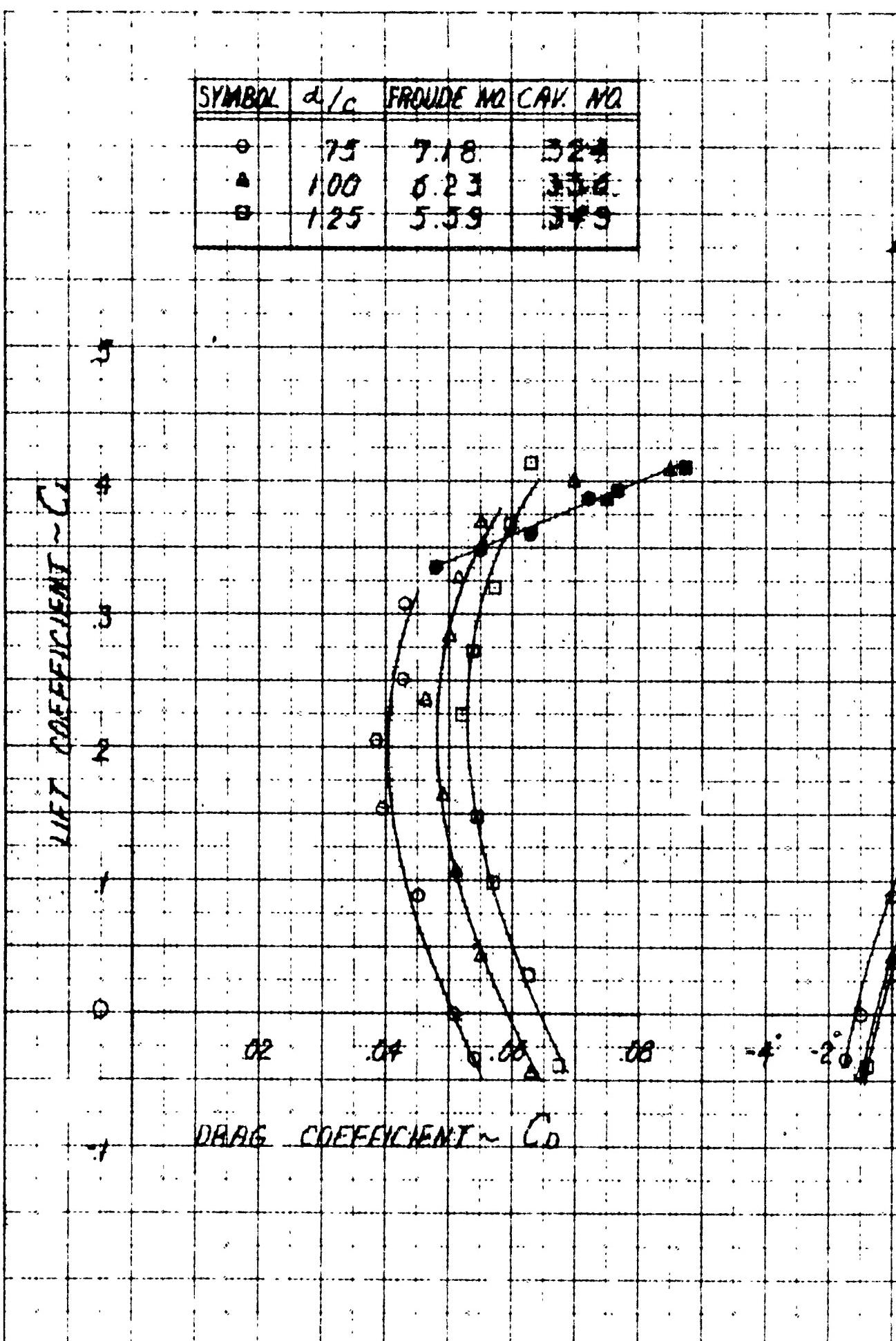
1. DARKENED POINTS INDICATE
VENTED FLOW.



SYMBOL	d/c	FROUDE NO CAV. NO
o	75	7.18 3.21
▲	100	6.23 3.56
■	125	5.59 3.73

LIFT COEFFICIENT - C_L

K-E geometry

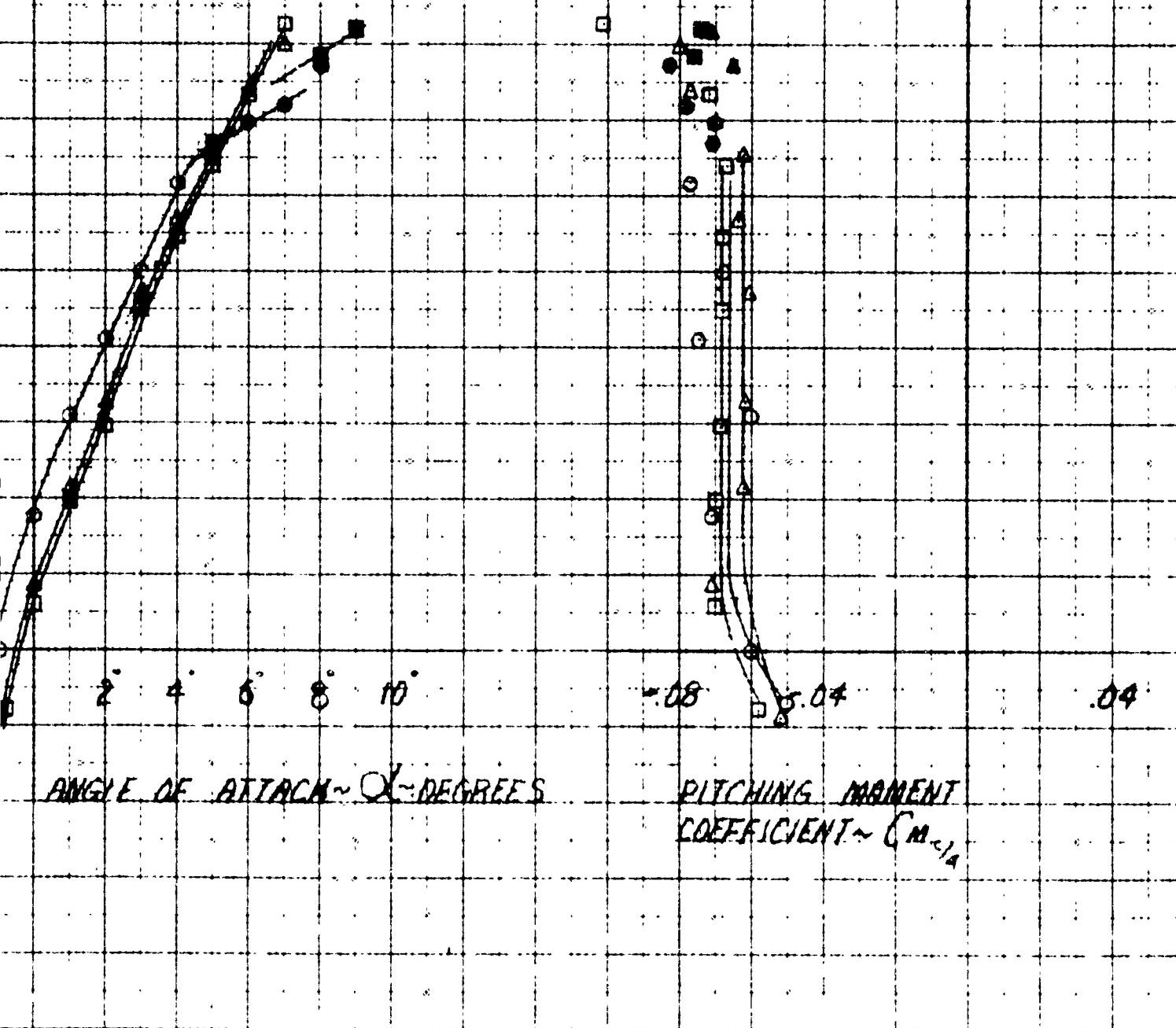


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WHIRLING TANK TEST NO. 50
BU SHIPS FOIL NO. 20
 $MAC = 110 FT.$; $S = 4.94 \text{ ft}^2$
 $V = 50 \text{ KTS.}$

NOTE:

1. DARKENED POINTS
INDICATE VENTED FLOW.



SYMBOL	d/c	FROUDE NO.	CAN NO.
○	.75	7.1767	237
△	1.00	6.2353	249
□	1.25	5.5949	261

15

4

3

2

1

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-1

LAT COEFF ~ C₁

0.02 0.04 0.06 0.08

-0.01 -0.03

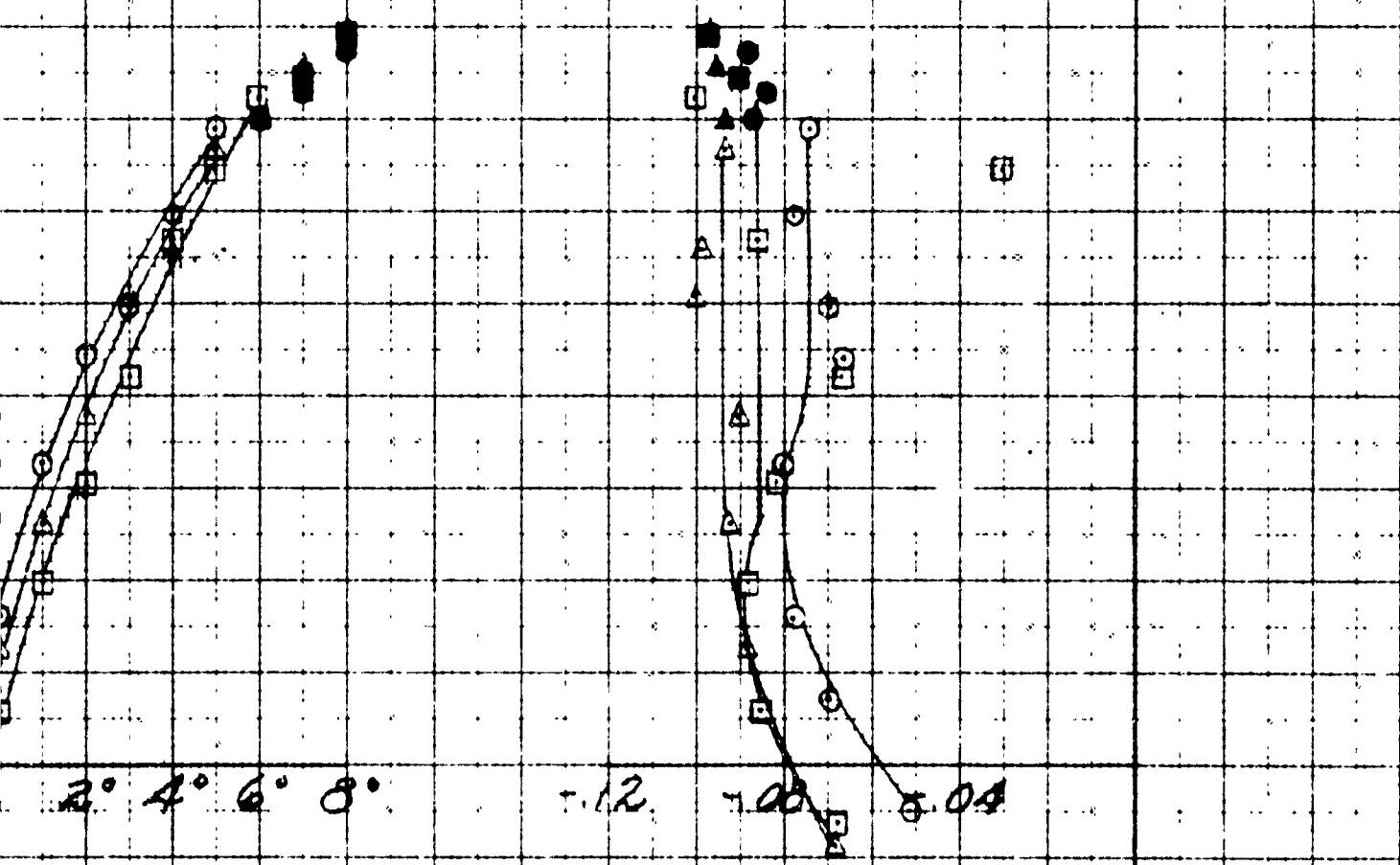
DRAG COEFF ~ C_D

ANGLE OF
DEGM

W. I. T. No. 50, Busnirs Foil No 20
M.A.C. = 110 FT. AREA = 4.94 ft^2
VEL. = 60 KTS

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW



OF ATTACK
DEGREES

PITCHING MOMENT COEFF

C_m

SYMBOL	d/c	FROUDE NO.	CAV. NO
O	.75	7.1767	1.84
▲	1.00	6.2353	1.96
B	1.25	5.5749	5.09

No
1.

N.E. alignment 52' 0"

Line CoffEE ~

-1

02

04

06

08

-1° -2° 0

TERR COFFEE ~ C

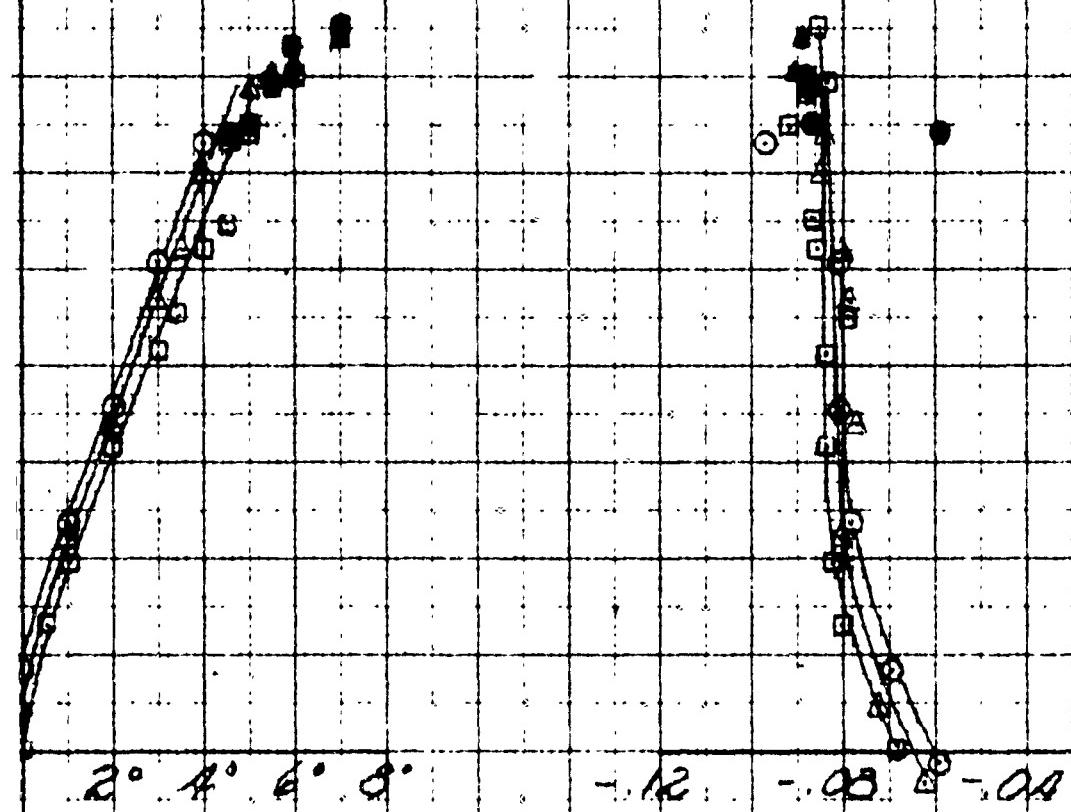
ANGLE
DE

PAGE IV.115

W.T.T. No.50 BuShips Foil No.20
M.A.G. = 110 FT AREA = 4.92 Δ "
VEL = 70 KTS

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.

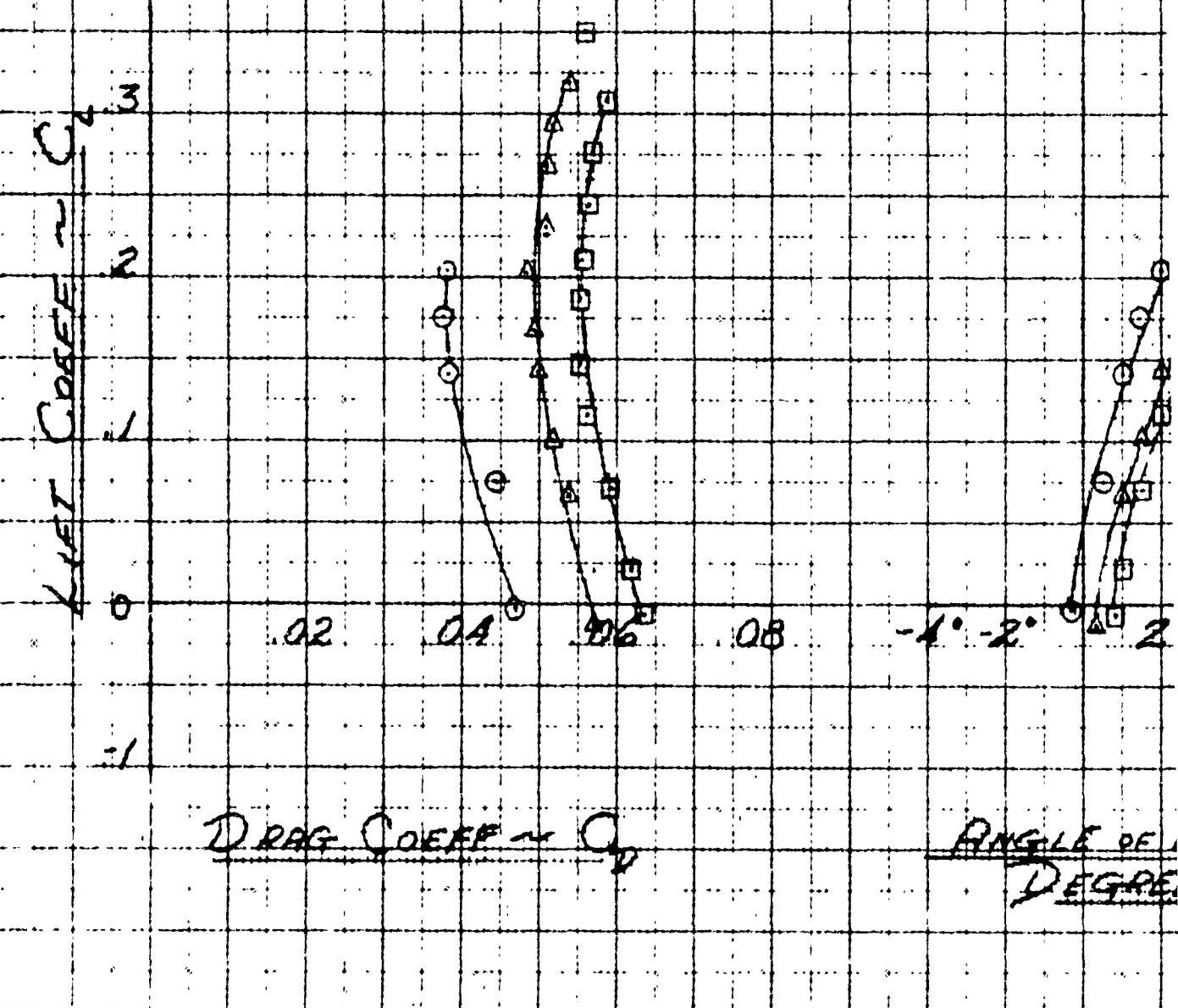


ANGLE OF ATTACK
DEGREES

PITCHING MOMENT COEFF

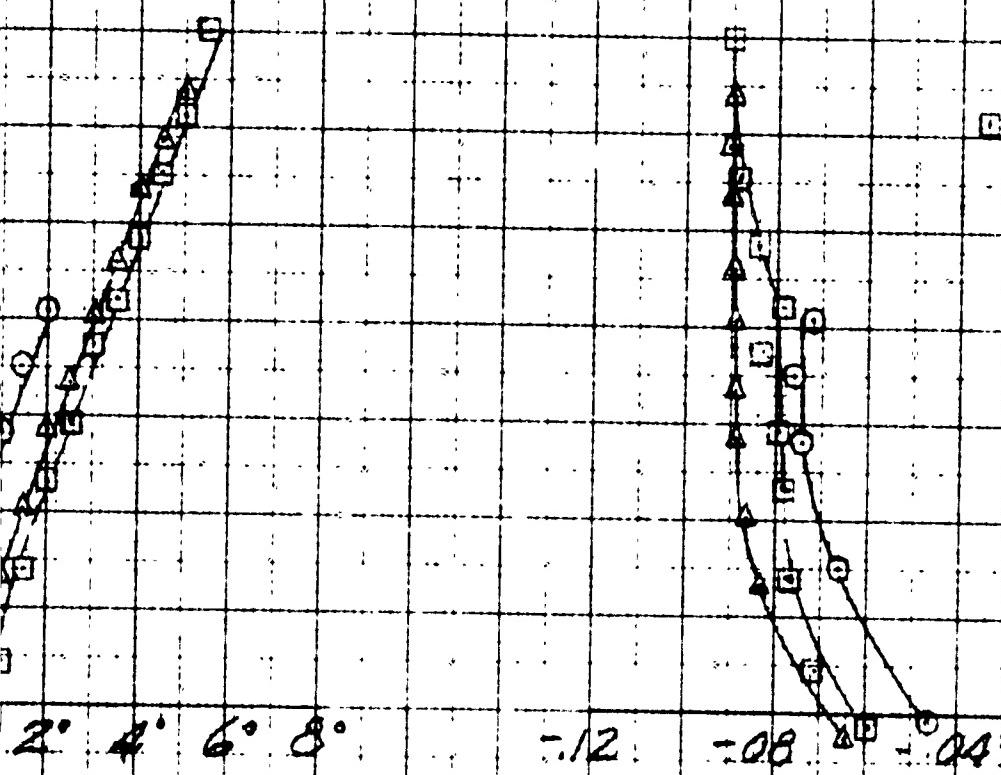
C_m
s₂

SYMBOL	d/c	FROUDE NO.	CAV. NO.
O	.75	7.1767	.150
△	1.00	6.2353	.153
□	1.25	5.5949	.175



PAGE IV.116

W.I.T. No. 50 Busnips Foil No. 20
M.A.C. = .110 FT AREA = 4.98 FT²
VEL = 80 KTS



2° 4° 6° 8° -12 -08 -04

OF ATTACK
DEGREES

TRIMMING MOMENT COEFF.
 C_m^s

SYMBOL	$\Delta x/c$	FROUDE NO.	CAV. NO.
○	.75	7.1767	.127
△	1.00	6.2353	.139
□	1.25	5.5949	.152

.5

.4

.3

.2

.1

.0

-1

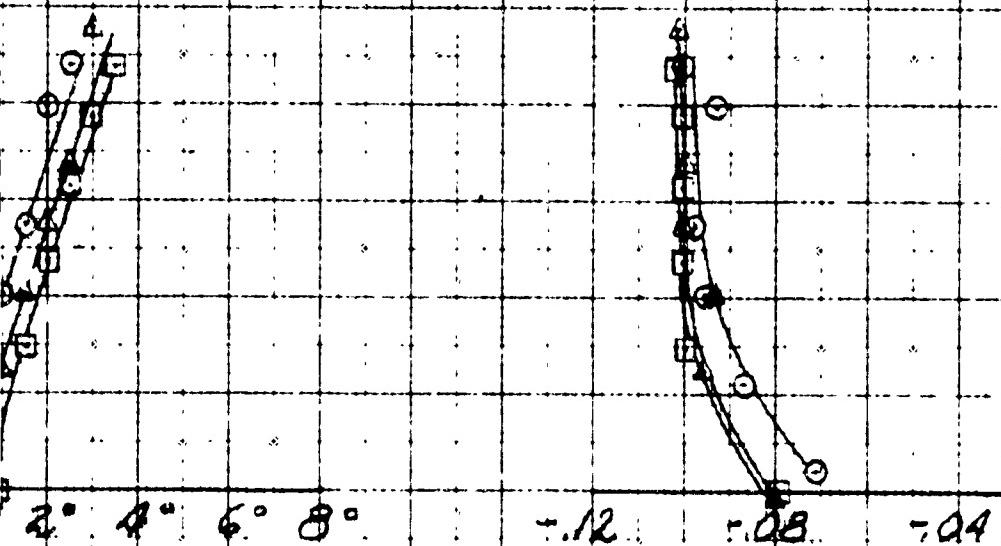
KE NUMBER

DRAG COEFF ~ CDRAG COEFF ~ CANGLE OF
DEGREE

.02 .04 .06 .08 -4° -2° 2°

PAGE IV.117

W.T.T. NO. 50 BUSNIPS FOIL NO. 20
M.A.C. = 110 FT. AREA = 4.940"
VEL. = 90 KTS



2° 4° 6° 8° -12° -8° -4°

DEGREE
OF ATTACK

PITCHING MOMENT COEFF.

C_m /%

SYMBOL	C/C	FROUDE NO.	CAV. NO.
O	.75		
▲	1.00	6.2353	133
□	1.25	5.5949	144

5

4

3

2

1

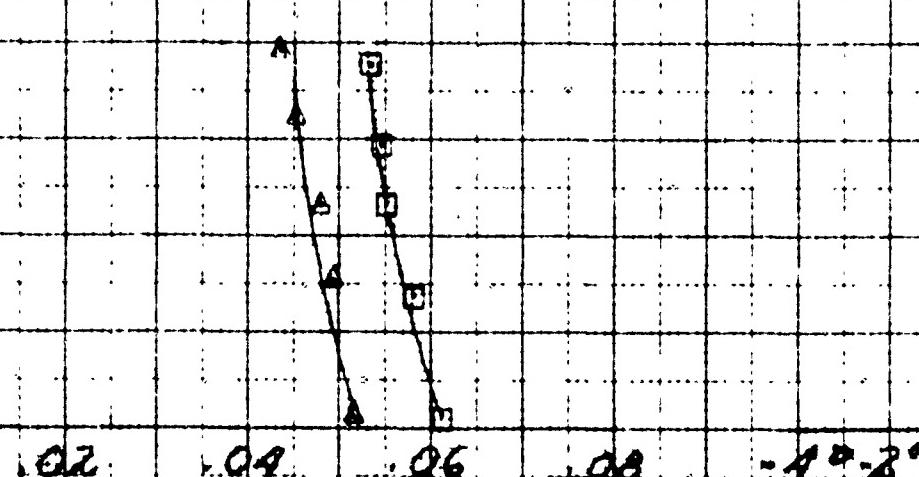
0

-1

-2

KE CONSTRUCTION

LET COEFF = C_D

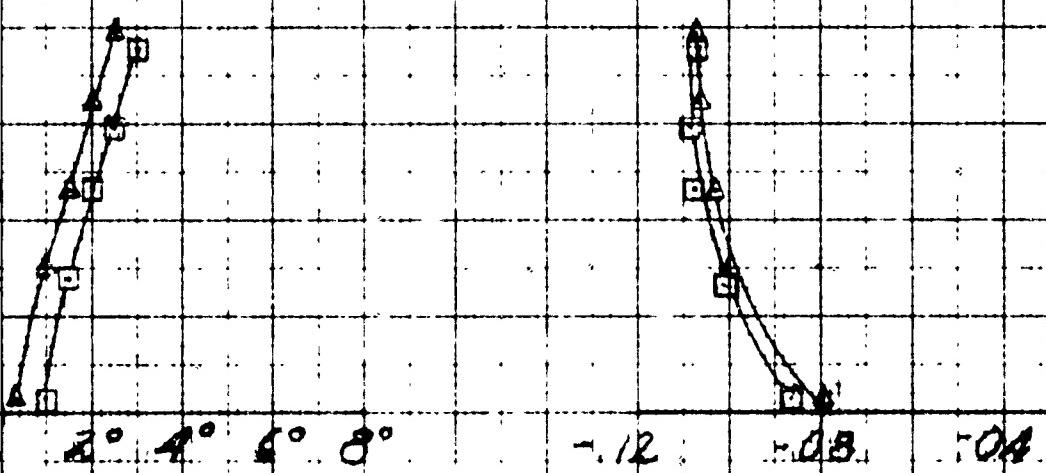


DRAG COEFF = C_D

ANGLE OF
DEGR

PAGE IV.11B

W.I.T. NO. 50 BUSHIPS FOIL NO. 20
M.A.C. = 110 FT AREA = 4.900"
WEI = 95 KTS



ANGLE OF ATTACK
DEGREES

PITCHING MOMENT COEFF.
 C_m

SYMBOL FLAP SET PROFILE NO. CAN NO.

0°

1°

6.1

12°

12

15°

3.4

20°

8.3

NO

Liter Coeff. of C_D

-1

DRAG COEFF. ~ C_D

ANGL

PAGE IV. 119

WHIRLING TANK TEST NO. 42

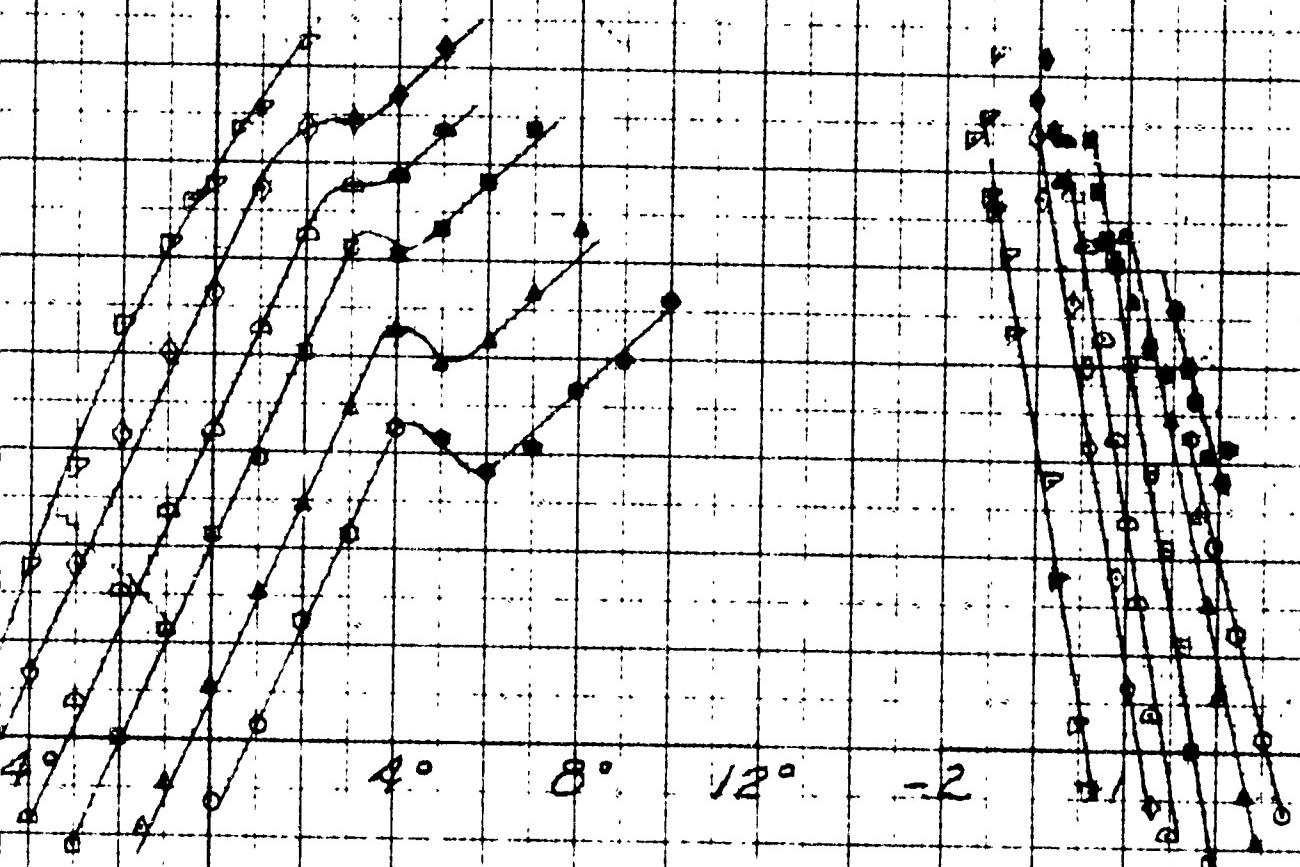
BUSHIPS FD14 NO. 13

MAC = 152 FT. DRA = 50" d/k = .75

VEL = 40 KTS

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW

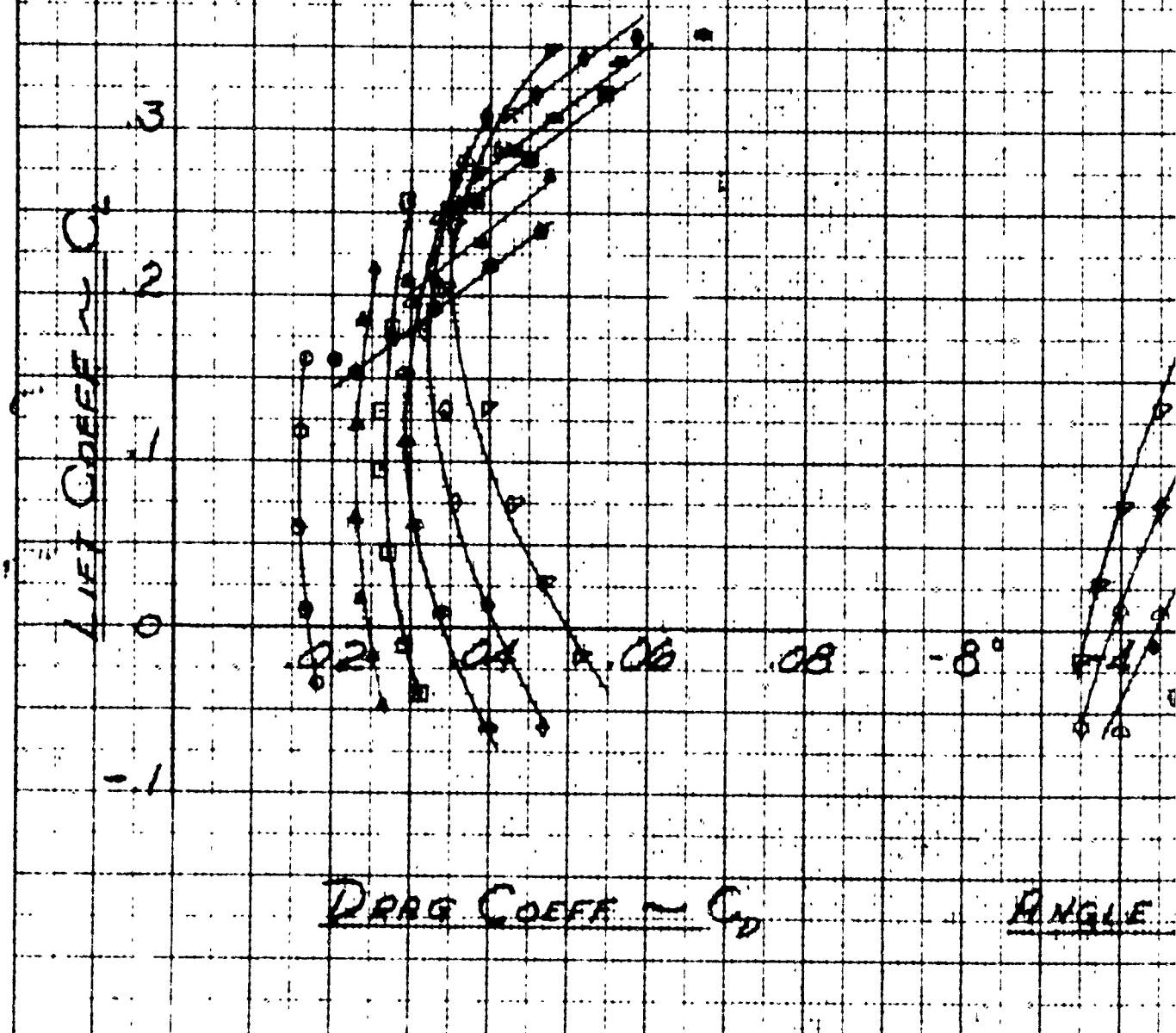


ANGLE OF ATTACK ~ DEGREES

PITCHING MOMENT
COEFF ~ C_m

94

SYMBOL	FLAP SET	FROUDE NO.	CAV. NO
○	0°		
△	4°	5	5
□	8°	3	1
○	12°	2	7
○	16°	19	
○	20°		



$DRAFT COEFF \sim C_D$

ANGLE

PAGE IV.120

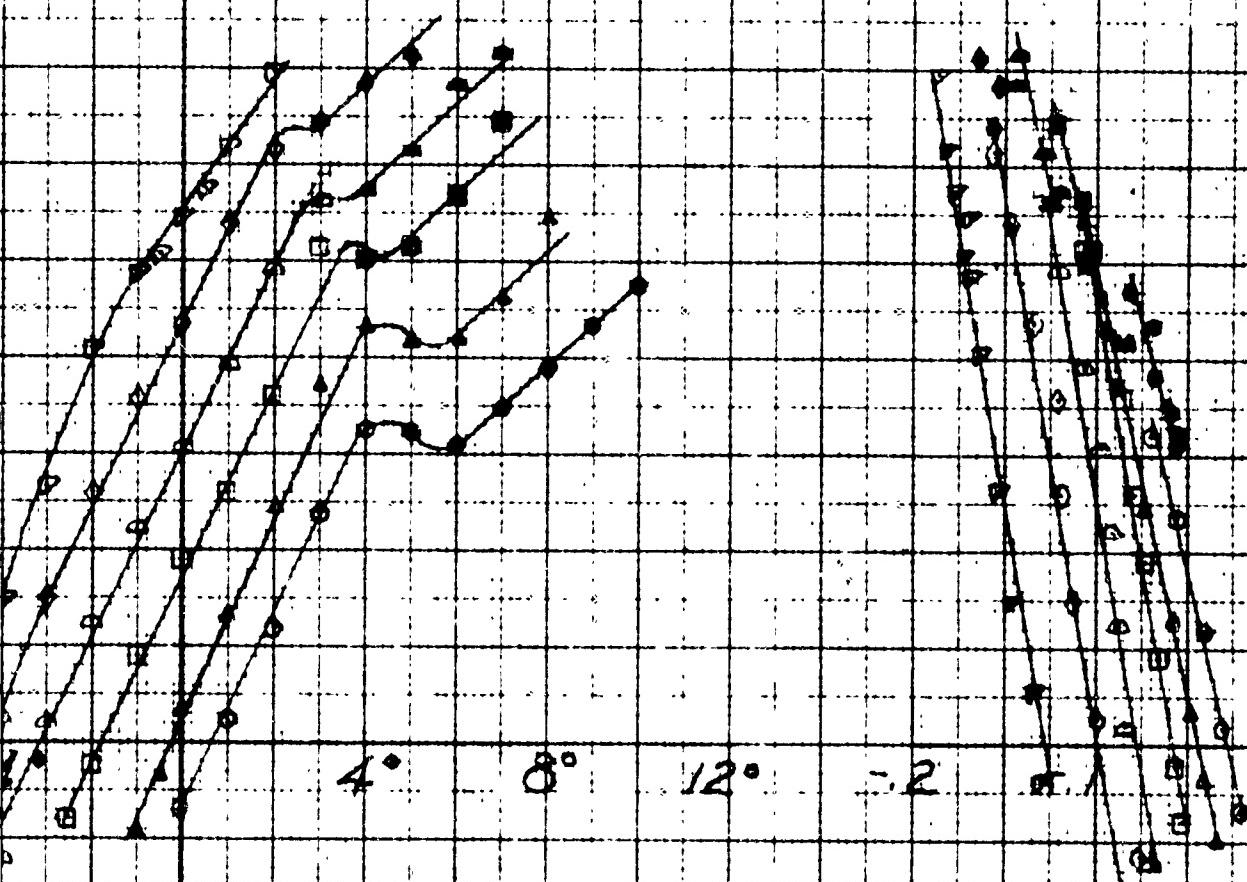
WHIRLING TANK TEST No. 42

BUSHNELL FOIL NO. 13

M.A.C. = 152 FT AREA = 80^{ft} $d_f = 1.00$
VEL = 40 KTS

NOTE:

1. DARKENED SYMBOLS
INDICATE VENTED FLOW.



ANGLE OF ATTACK - DEGREES

PITCHING MOMENT
COEFF. ~ $C_{M, \infty}$

SYMBOL FLAP SET FORWARD NO. CAV NO.

0

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12

16

20

24

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NOTE:
1 DRAG
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C₂

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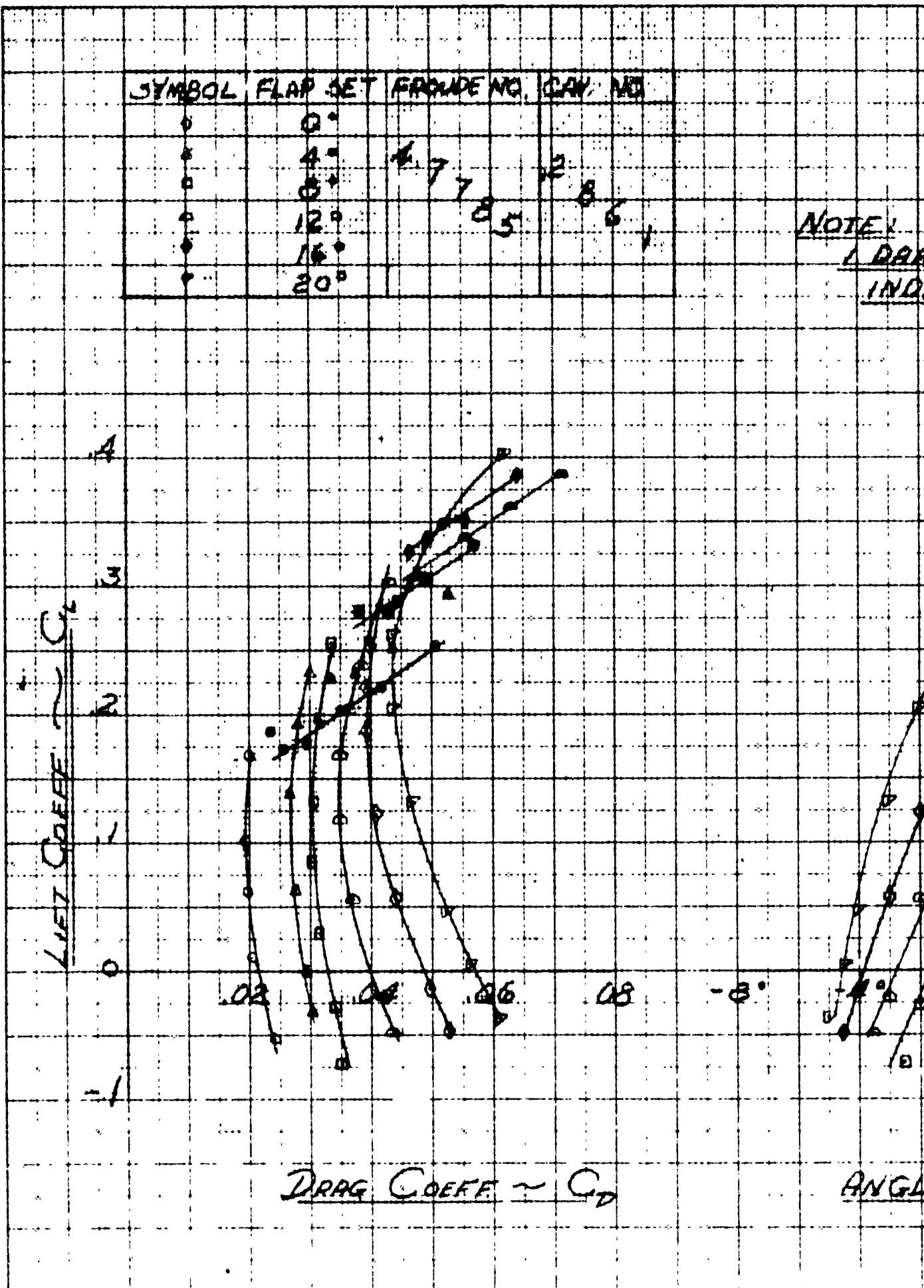
-1

-2

-3

DRA G COEFF ~ C_D

ANGL



PAGE IV. 121

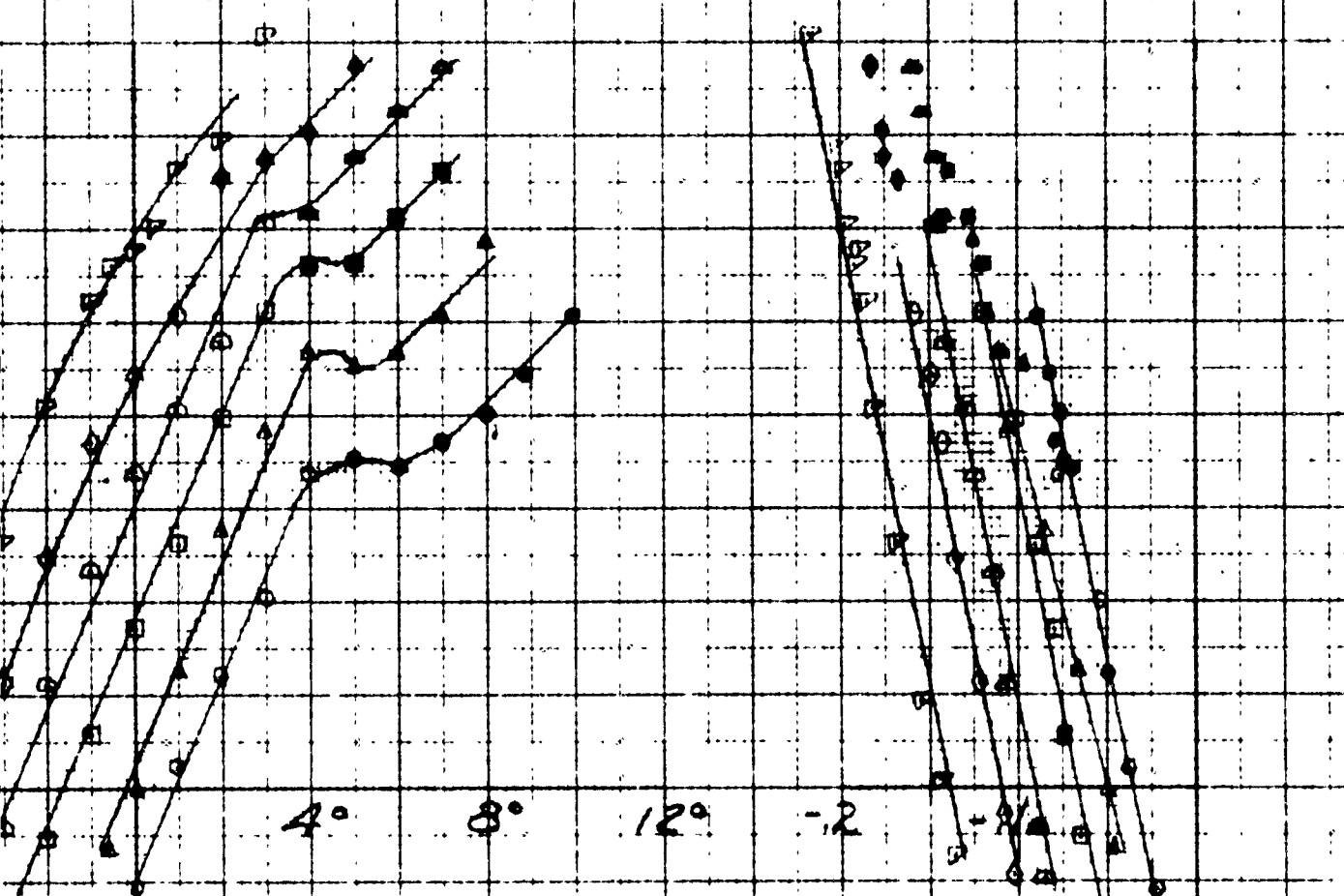
MEASURING TANK TEST NO 42.

BUSHIPS FORM NO. 13.

M.A.C. = 152 FT QDEG = 84° 4/5 125
VEL. = 40 KTS

VEL. = 40 KTS

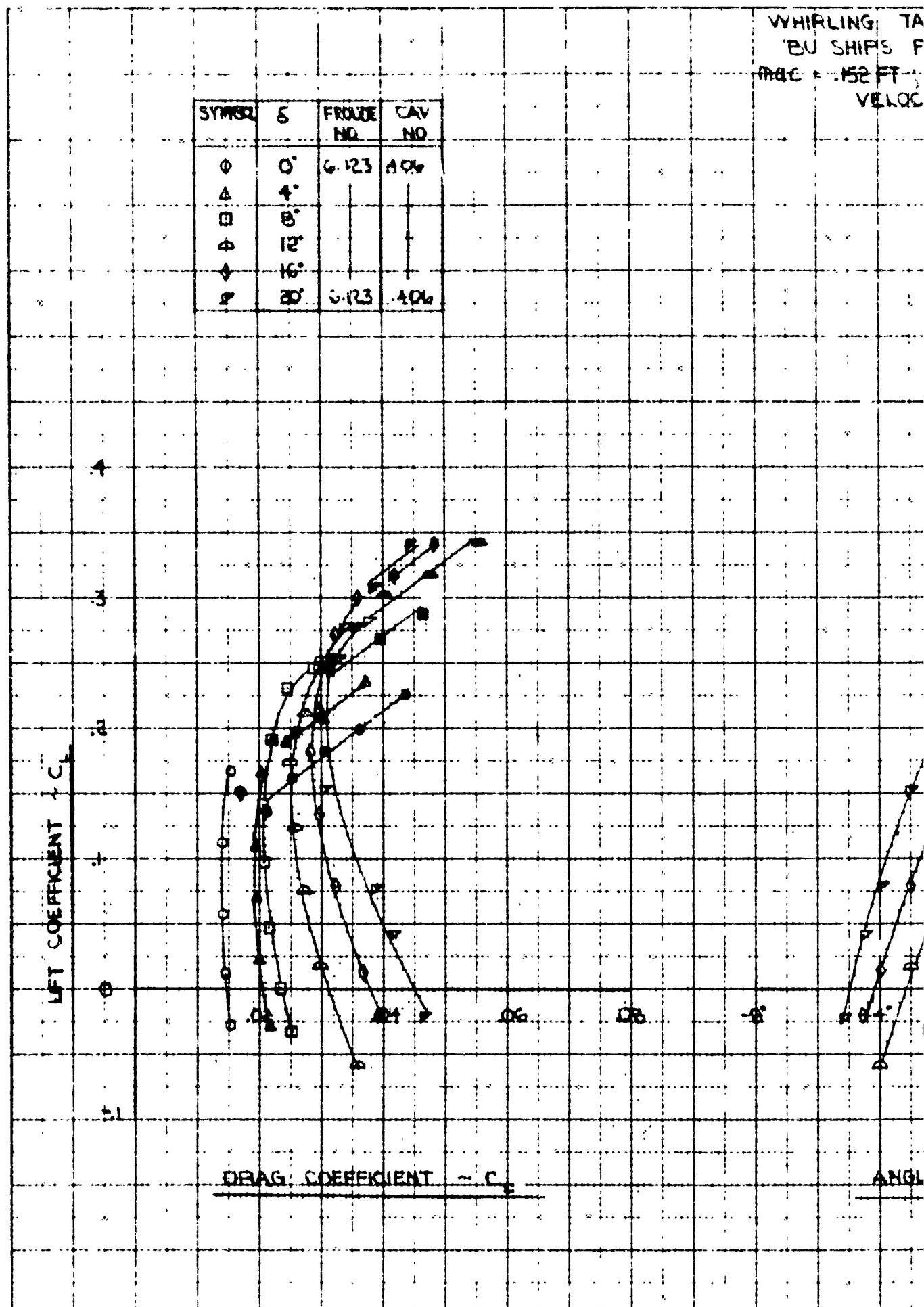
DARKENED SYMBOLS
INDICATE VENTED FLOW.



GLE OF ATTACK - DEGREES

DITCHING MOMENT
COEFF. ~ C_H

WHIRLING TA
'BU SHIPS F
MAGC = -152 FT-
VELAC



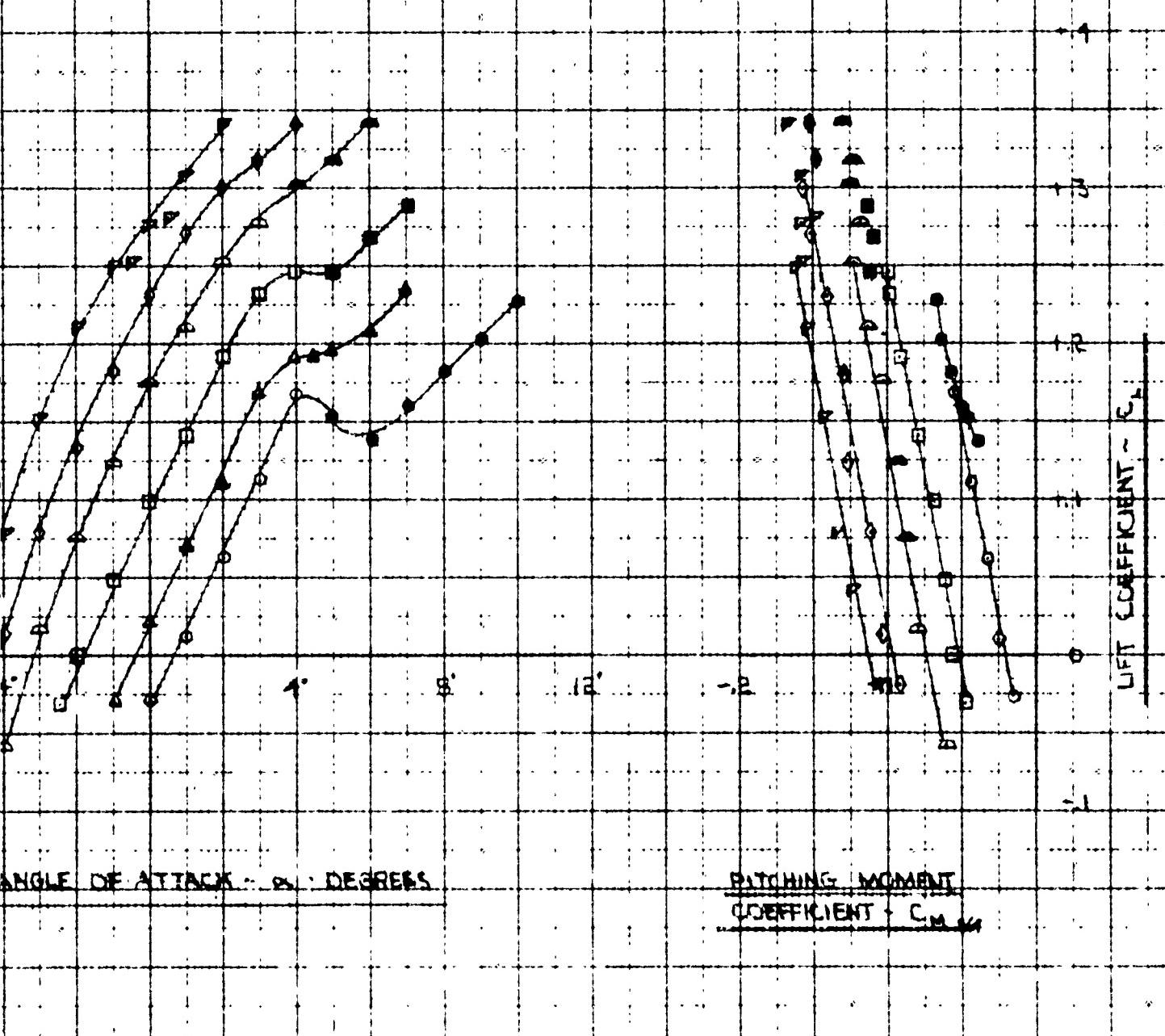
TANK TEST NO 42

S FOIL NO 13

FT. 5.80500 DATE .75
VELOCITY : 45 KTS

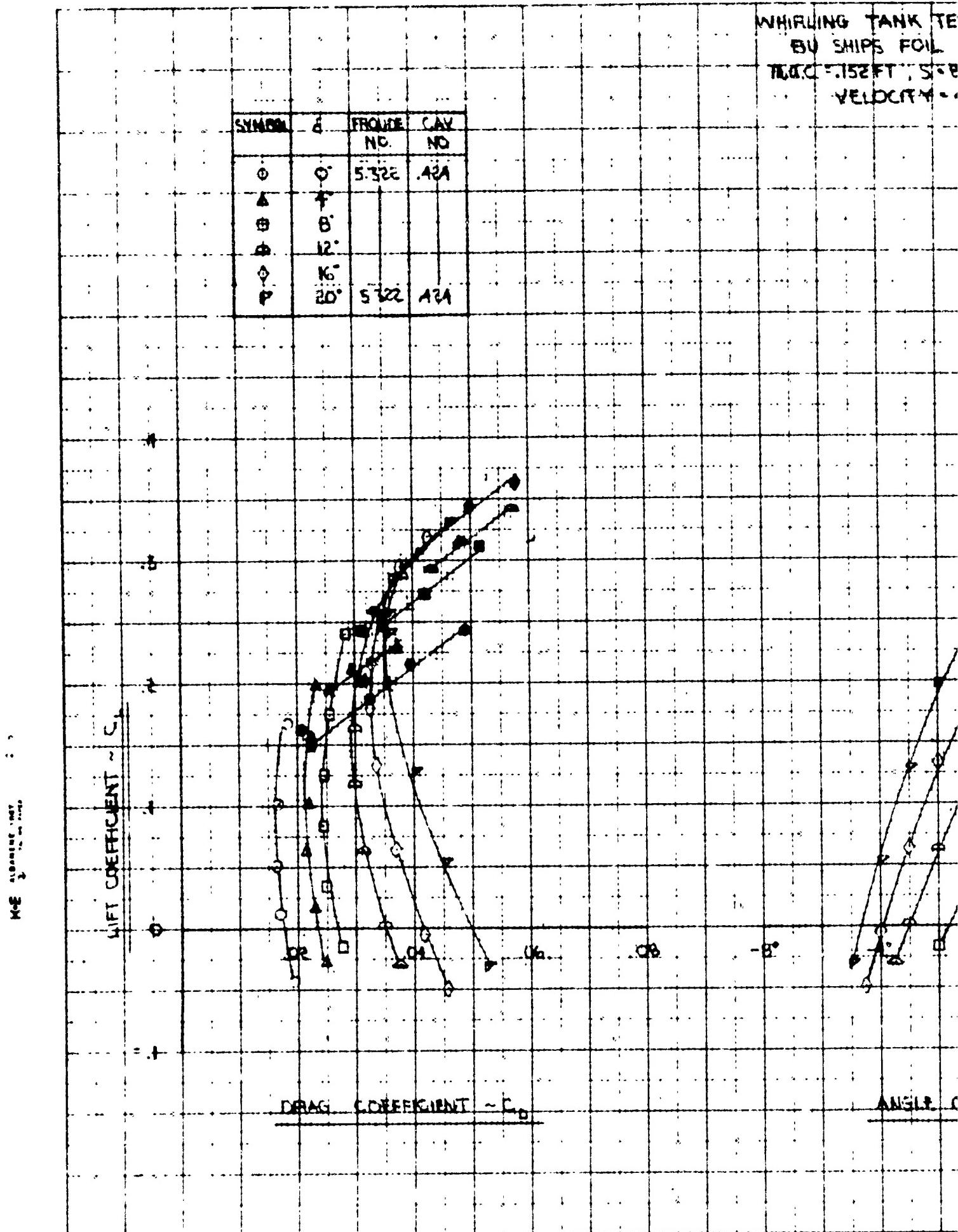
PAGE IV.122

NOTE DARKENED POINTS INDICATE VENTED FLOW



WHIRLING TANK TEST
BY SHIPS FOIL
TALL: .152 FT. SCALED
VELOCITY -

SYMBOL	θ	FRONDE CAV.	NO.	NO.
○	0°	5.32E	.42A	
▲	4°			
□	8°			
◆	12°			
◇	16°			
◆	20°	5.322	.42A	



TEST NO 12

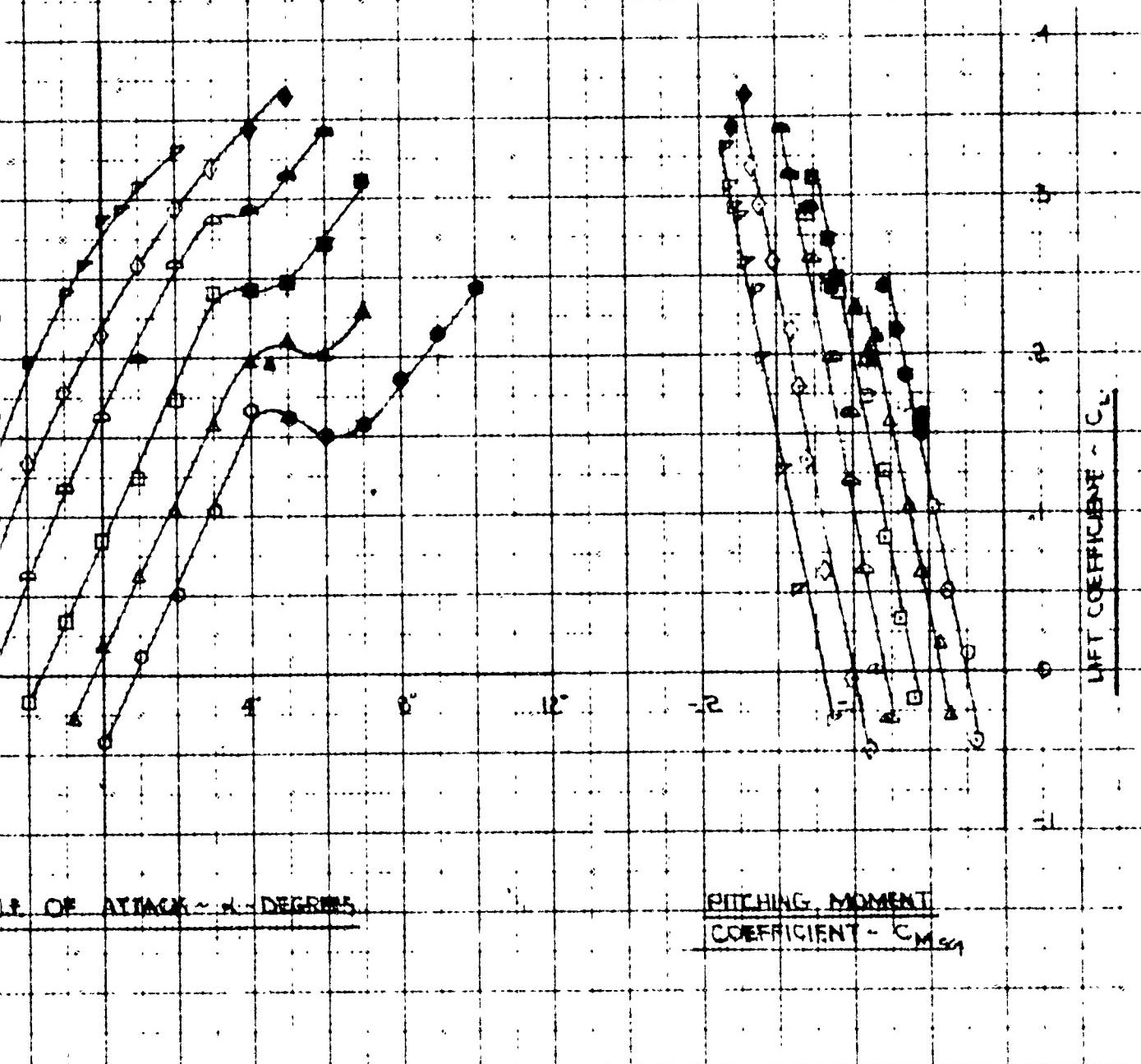
OIL NO 13

S = 800 SQ IN, DR = 1.00

H = 45 KTS.

PAGE IV.123

NOTE: DARKENED POINTS INDICATE VENTED FLOW



WHIRLING TANK
BU SHIPS FO
M.O.D. - 152 FT,
VELOCITY

SYMBOL	θ	FROUD NO.	CAV. NO.
○	0°	4.378	438
△	4°		
□	8°		
○	12°		
○	15°		
△	20°	4.378	438

K-E INSTRUMENTS INC.

NET COEFFICIENT - C_D

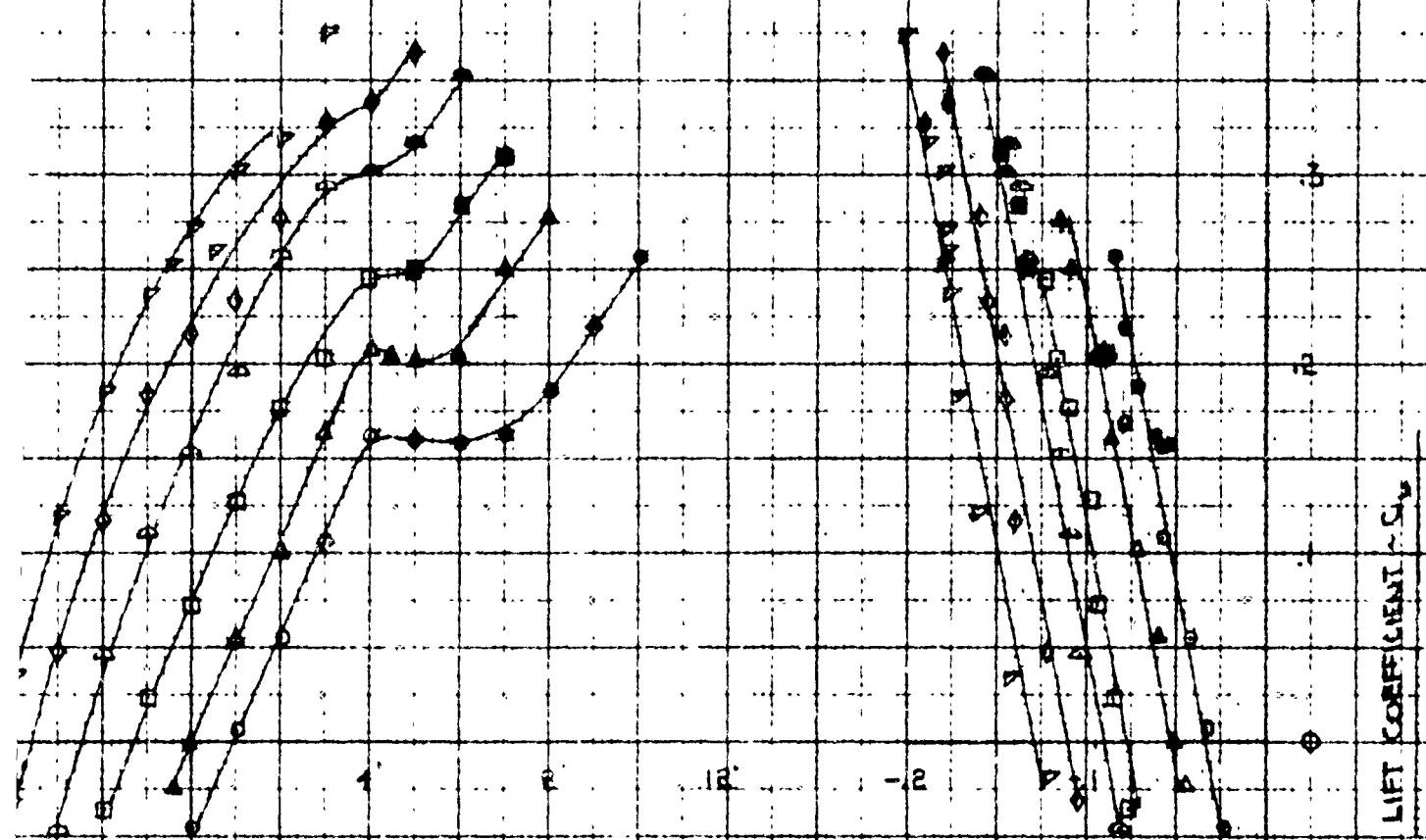
DRAG COEFFICIENT - C_D

ANGLE

CANK TEST NO K2
FOIL NO 1B
T = 5.800 SQ IN, Q/R = 1.85
ATY = 45 KTS

PAGE 1K124

NOTE: DARKENED POINTS INDICATE VENTED FLOW



ANGLE OF ATTACK = 0 DEGREES

PITCHING MOMENT
COEFFICIENT = C_m

WHIRLING TA
BY SHIPS
MAC = 158 FT
VELOCITY

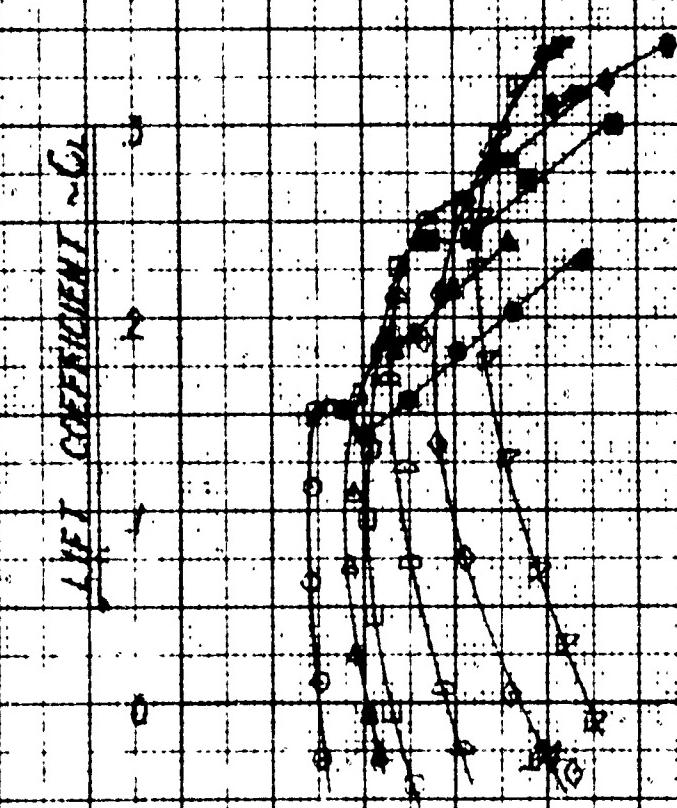
SYMBOL δ FAILURE CRITICAL ANGLE α_f

SYMBOL	δ	FAILURE CRITICAL ANGLE α_f	ANGLE α	ANGLE β
⊕	0°	6	3	
△	4°	1		
□	8°	1	*	
◆	12°	2	1	
◇	16°			
⊗	20°			

LIFT COEFFICIENT $\sim C_L$

ANGLE OF INCIDENCE α

ANGLE OF INCIDENCE α



DRAG COEFFICIENT $\sim C_D$

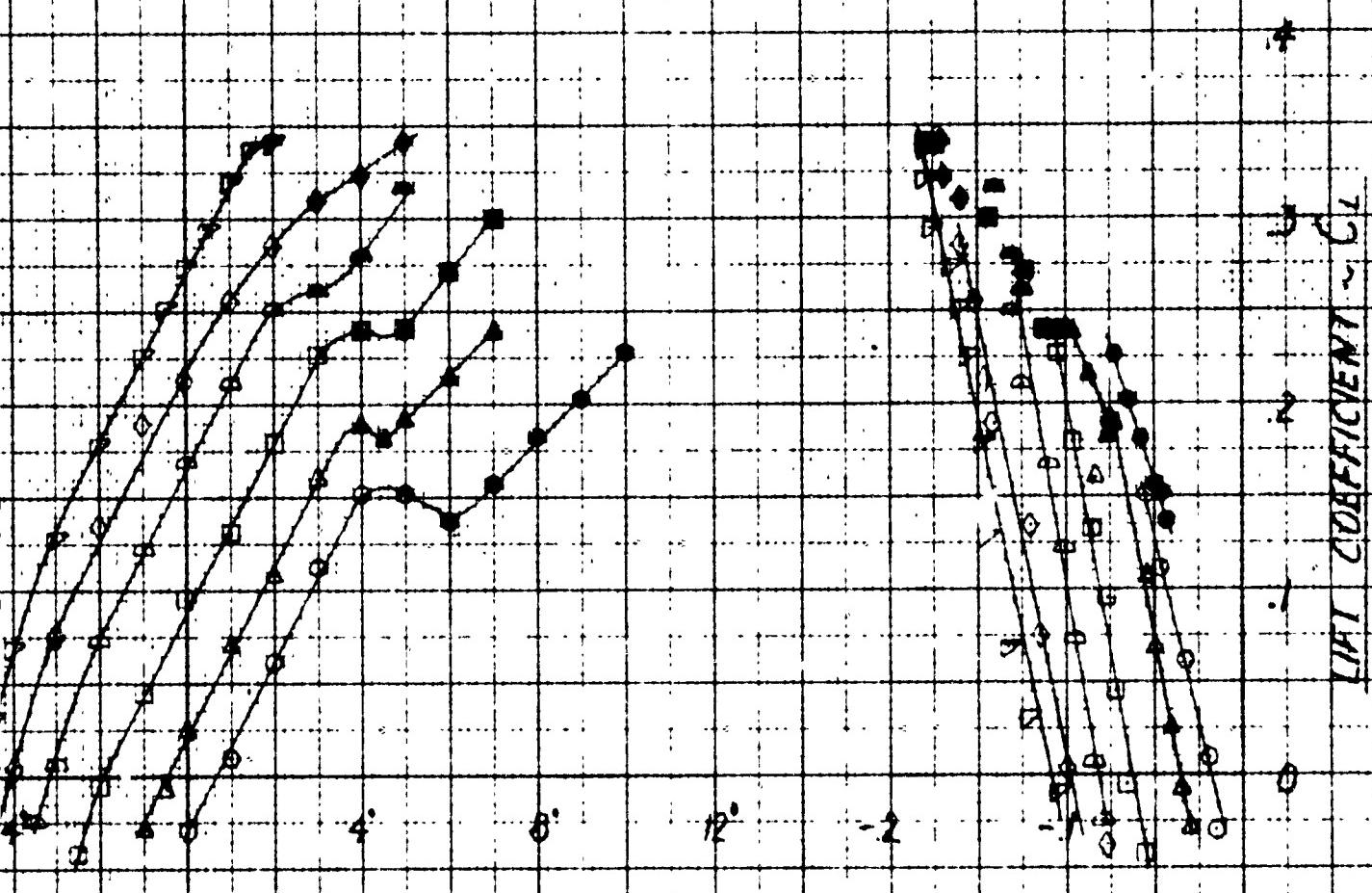
TANK TEST NO. 42

IPS ROD NO. 13

8 FT ; S = 8.00 IN² ; $\alpha_c = 75$

OCITY = 50 MTS.

NOTE: DARKENED SYMBOLS INDICATE VENTED FLOW.

ANGLE OF ATTACK ~ α ~ DEGREESPITCHING MOMENT
COEFFICIENT ~ C_M

WHIRLING
BY SHIPS
MAC = 152 FT.
VELOC

SYMBOL	S	FROUDE NO.	CAN NO.
○	0°	5	3
△	4°		
□	8°	3	5
◆	12°		
▽	16°	2	7
◇	20°		

JET COEFFICIENT - C_J

MEASUREMENTS

DRAG COEFFICIENT - C_D

AM

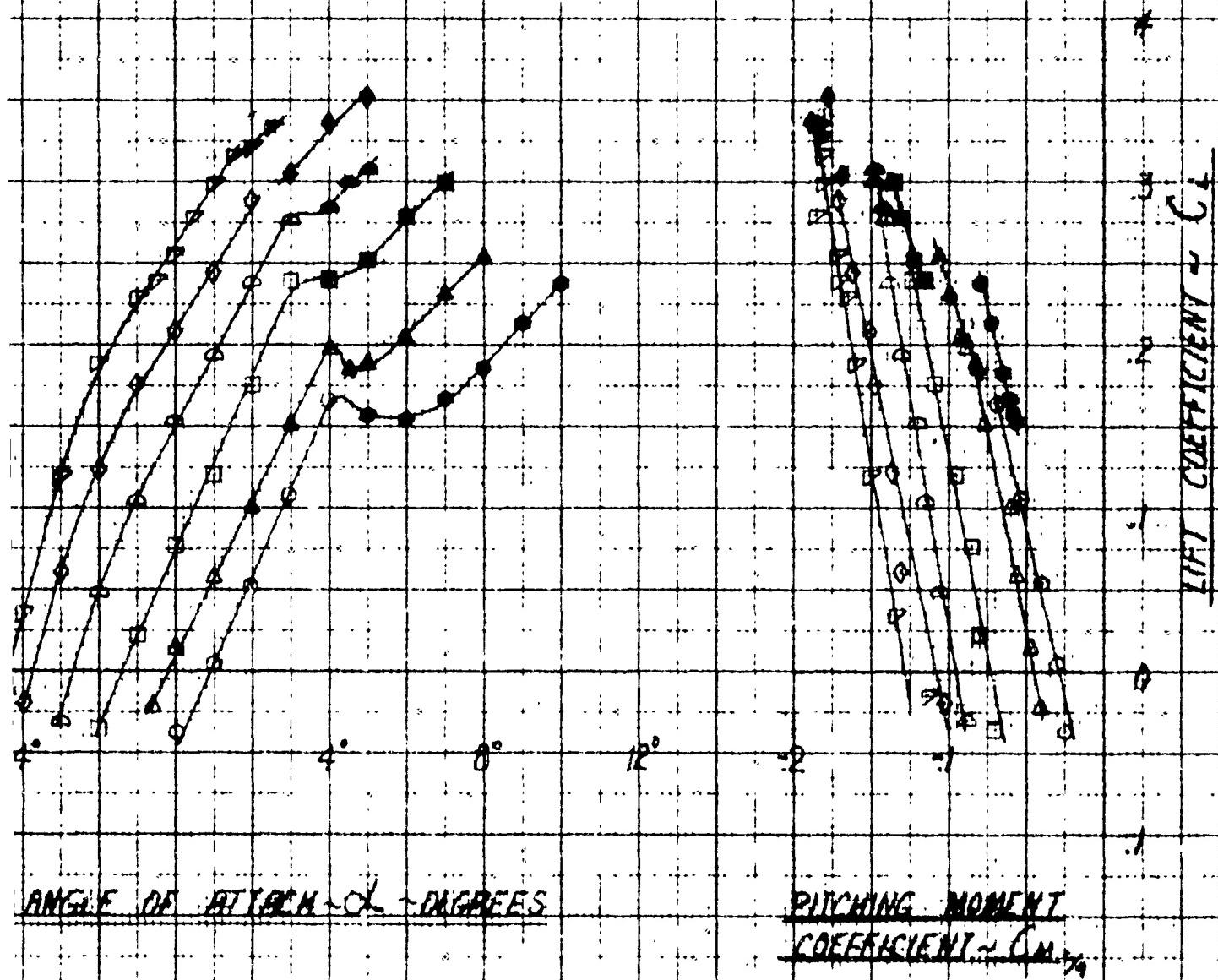
G. TANK TEST NO. 2.

HIPS FOIL NO. 13

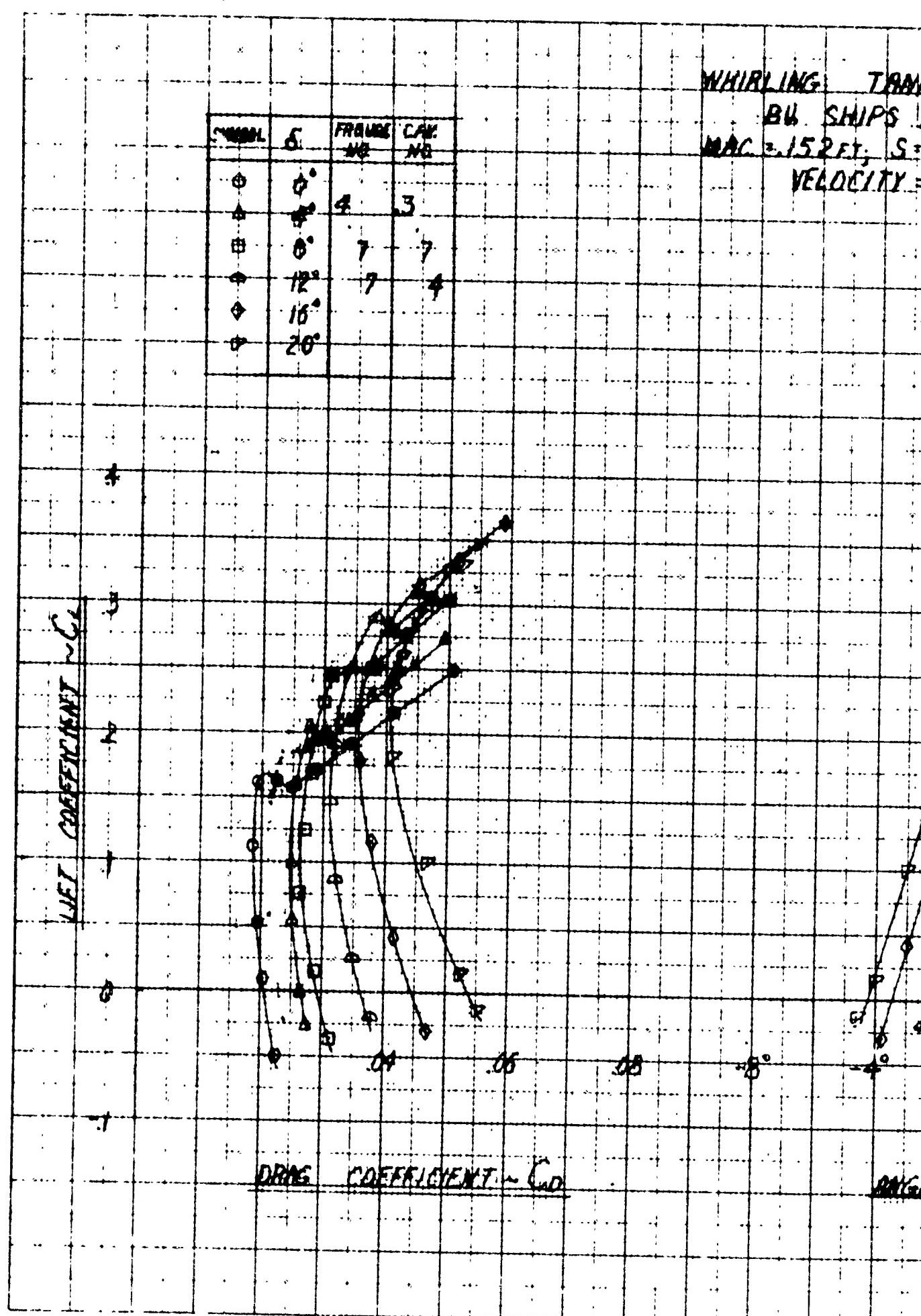
2 FT; $S = 8.00 \text{ IN}^2$; $\frac{C}{L} = 1.00$

VELOCITY = 50 MTS.

NOTE: DARKENED SYMBOLS INDICATE VENTED FLOW.



WHIRLING TRAIN
BU. SHIPS
MAC = .152 FT. S.
VELOCITY



DRAG TEST NO. 42

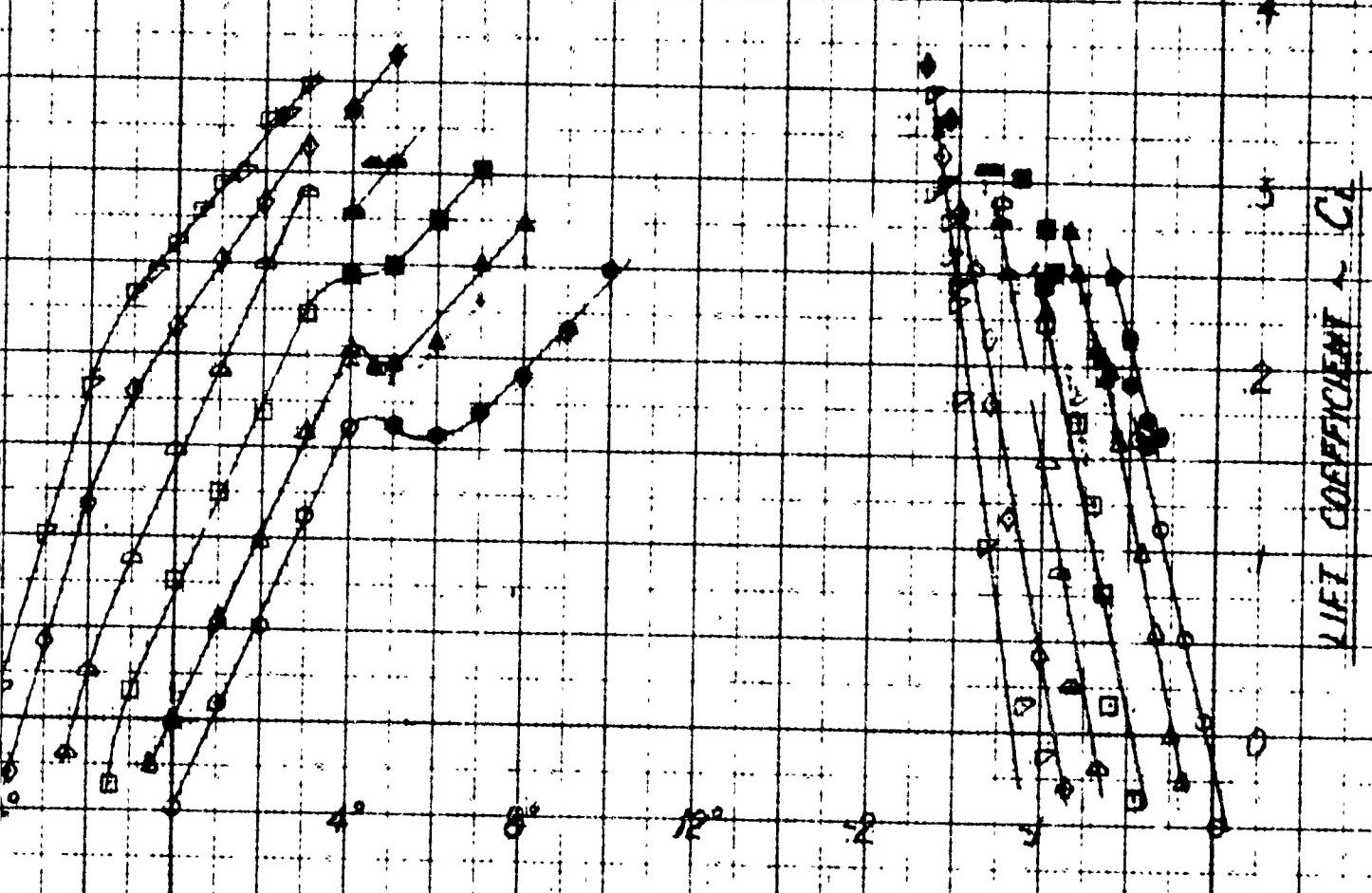
PS FOIL NO. 13

$S = 0.0001 \text{ ft}^2$; $d/c = 1.25$

$T_y = 50 \text{ KTS}$

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NOTE: DARKENED SYMBOLS INDICATE VENTED FLOW.



ANGLE OF ATTACK ~ α ~ DEGREES

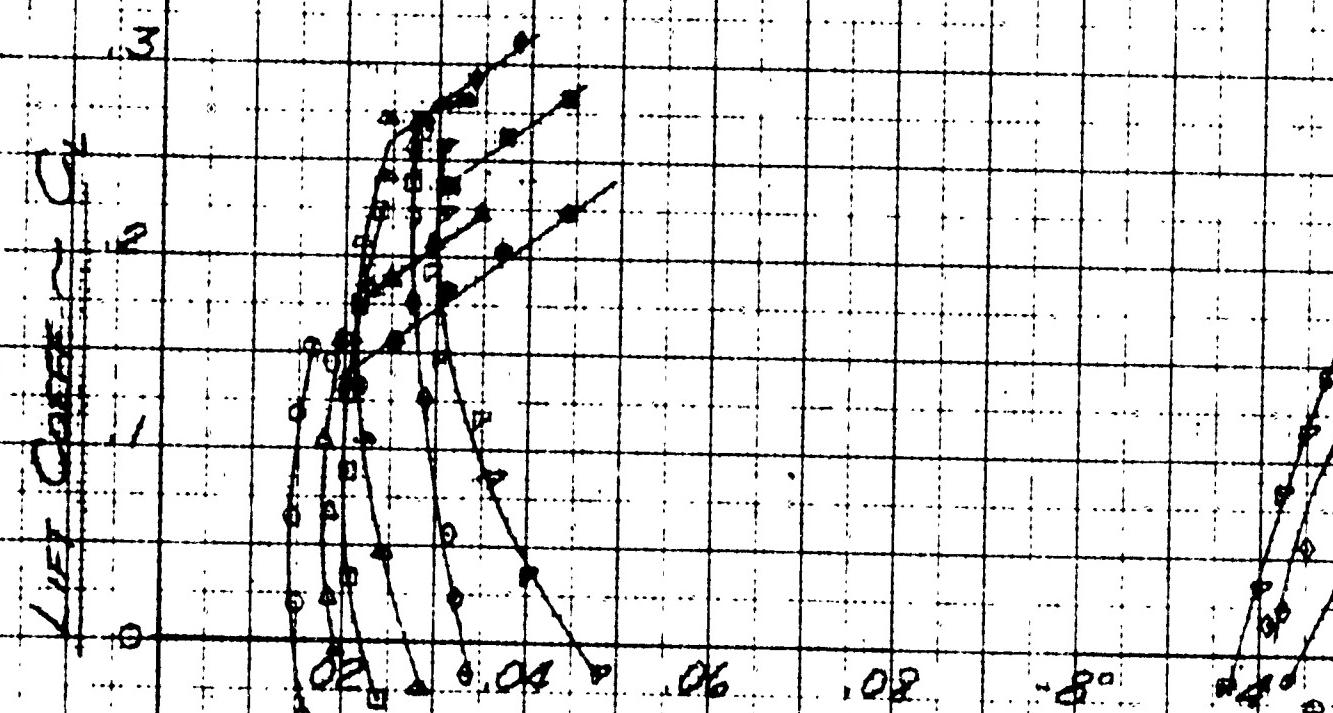
PITCHING MOMENT
COEFFICIENT ~ C_M ~

SYMBOL FLAP SET FROUDE NO. CAV. NO.

0° 4° 6° 7° 2° 5°
4° 8° 12° 13° 4° 8°
8° 12° 16° 14° 2° 8°
12° 16° 20°

NOTE

10
15



DRAG COEFF. - C_D

ANGLE

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WHIRLING TRAIL TEST NO 42

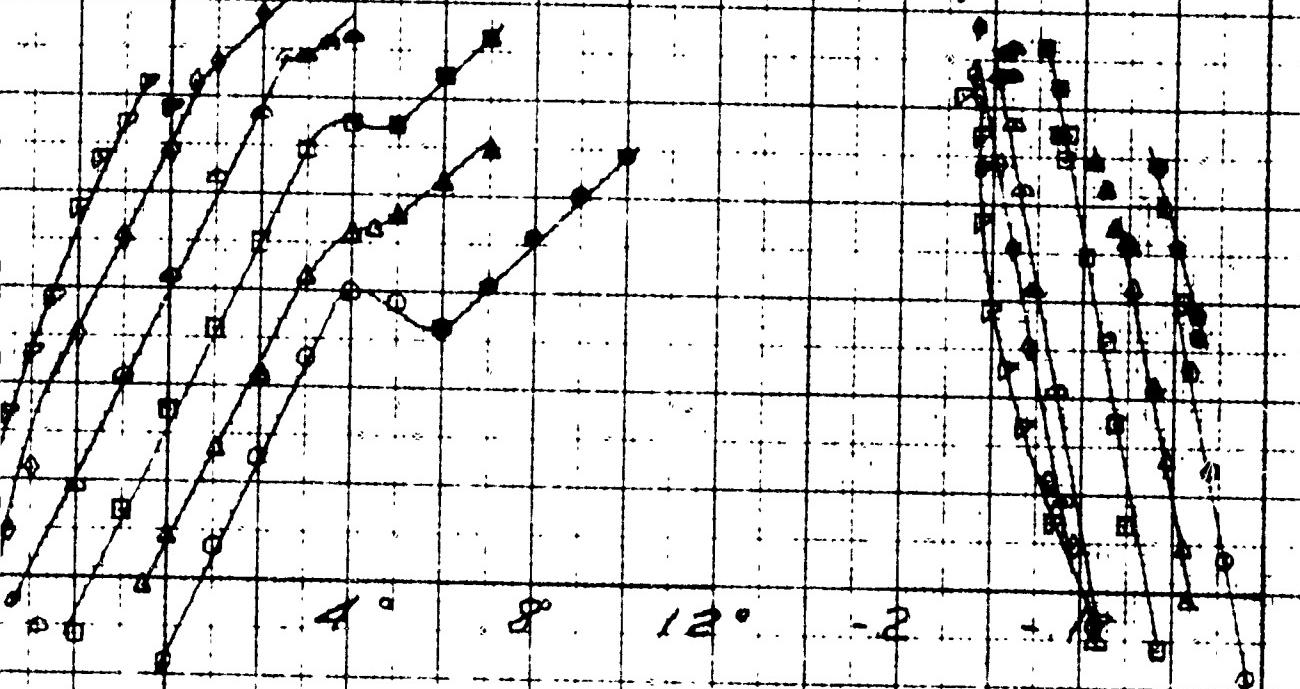
BUSHIPS FOIL NO 13

MAC = 152 FT AREA = 80" $\delta_1 = 7.5$
VEL = 60 KTS

TE

DARKENED SYMBOLS
INDICATE VANTED FLOW.

Ref. Drawing 3-K



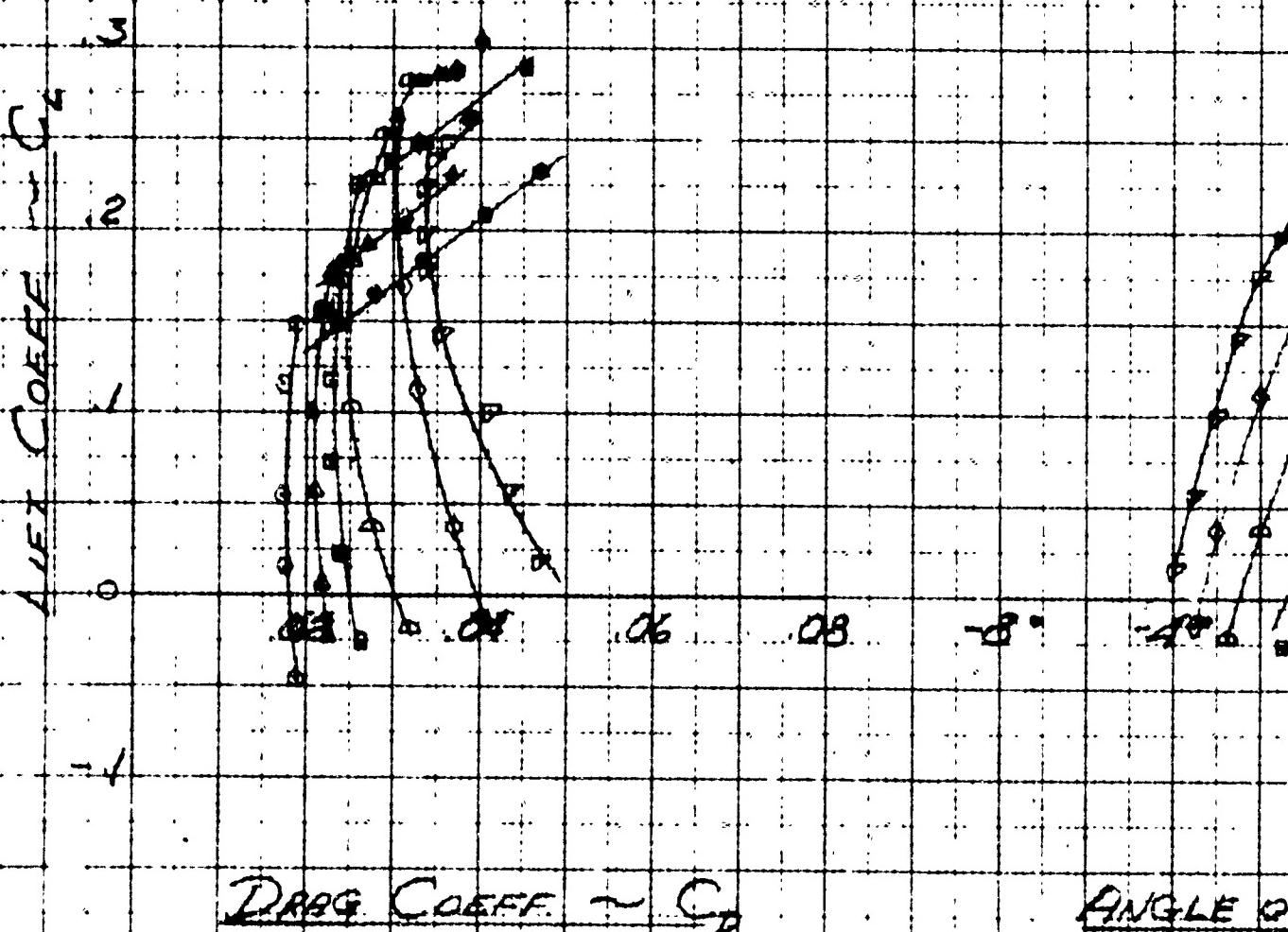
ANGLE OF ATTACK - DEGREES

PITCHING MOMENT
COEFF - CM⁻¹

SYMBOL FLAP SET FROUDE No CAV. No.

0°	0°				
4°	5.3	27			
8°	2	19	70		
12°					
16°					
20°					

NOTE
1. DA
INL



DRAG COEFF. ~ C_D

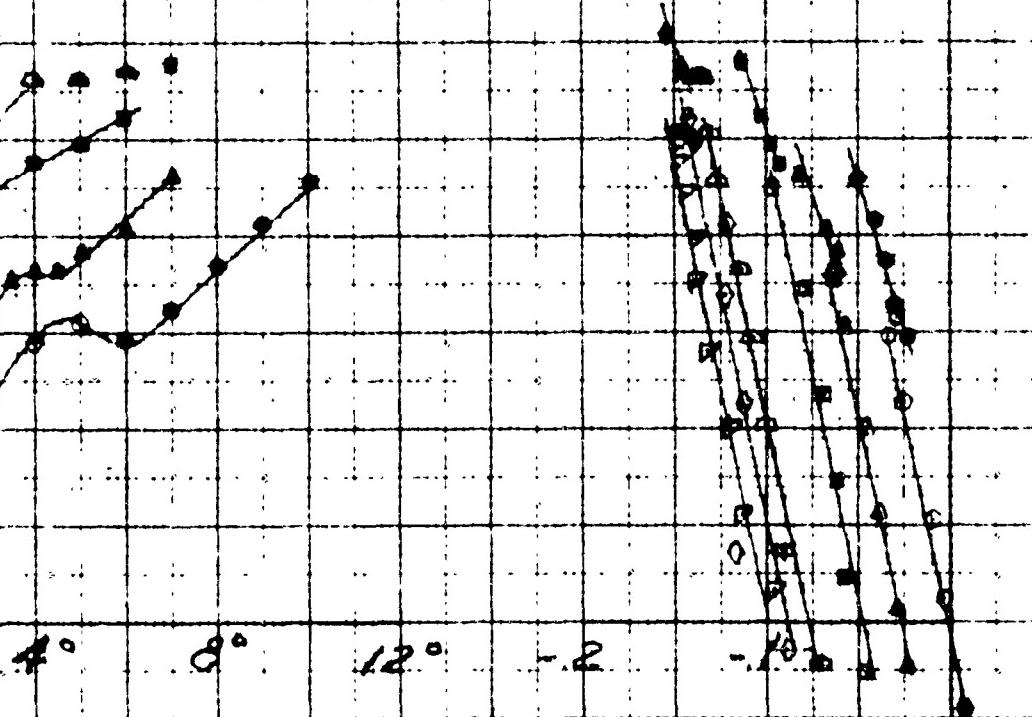
ANGLE α

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WINDING TANK TEST NO. 42

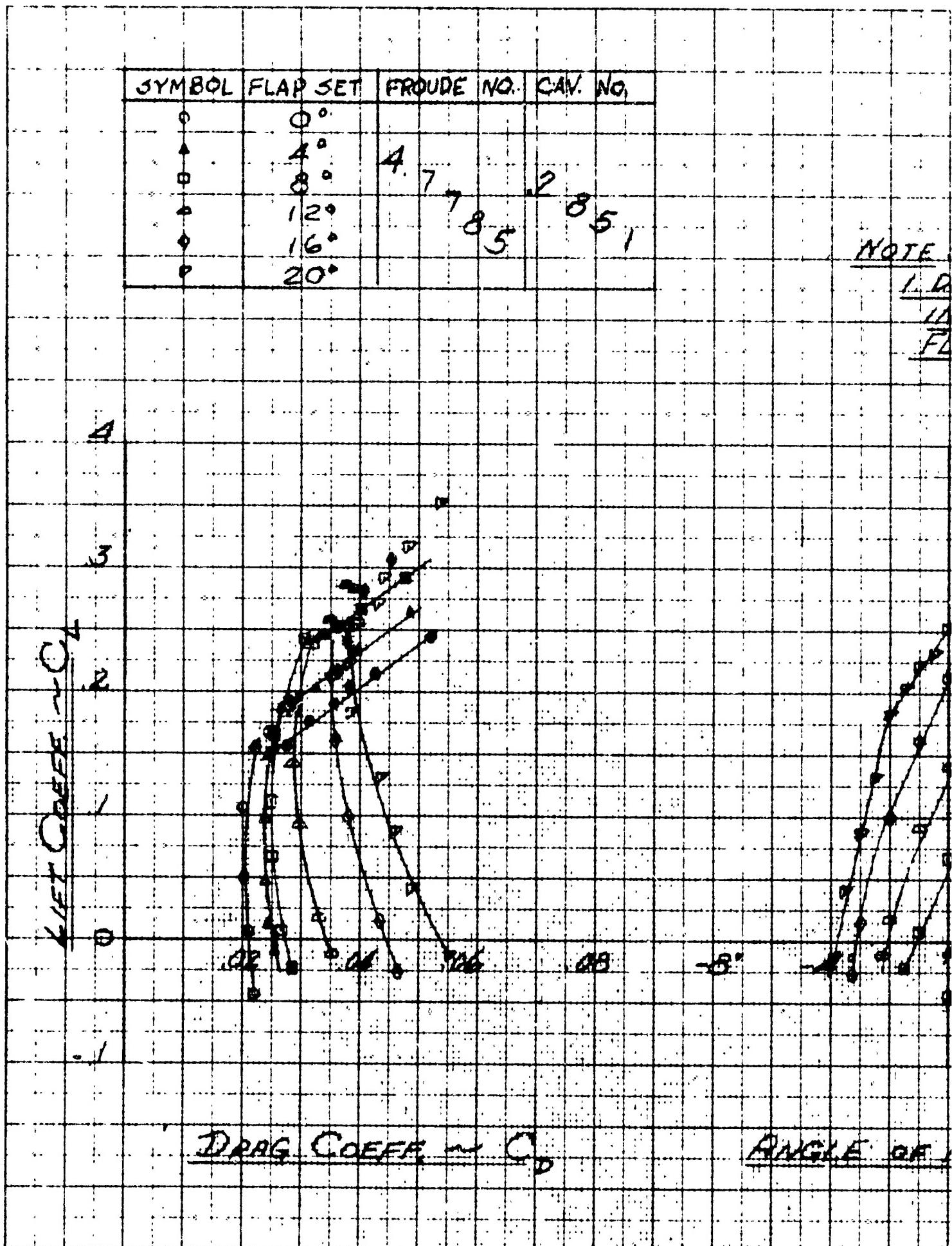
BUSHIPS FOIL NO. 13
M.A.C. = 152 FT AREA = 88² d/2 1.00
VEL = 60 KTS

DARKENED SYMBOLS
INDICATE VENTED FLOW.



ANGLE OF ATTACK - DEGREES

PITCHING MOMENT COEFF - C_M



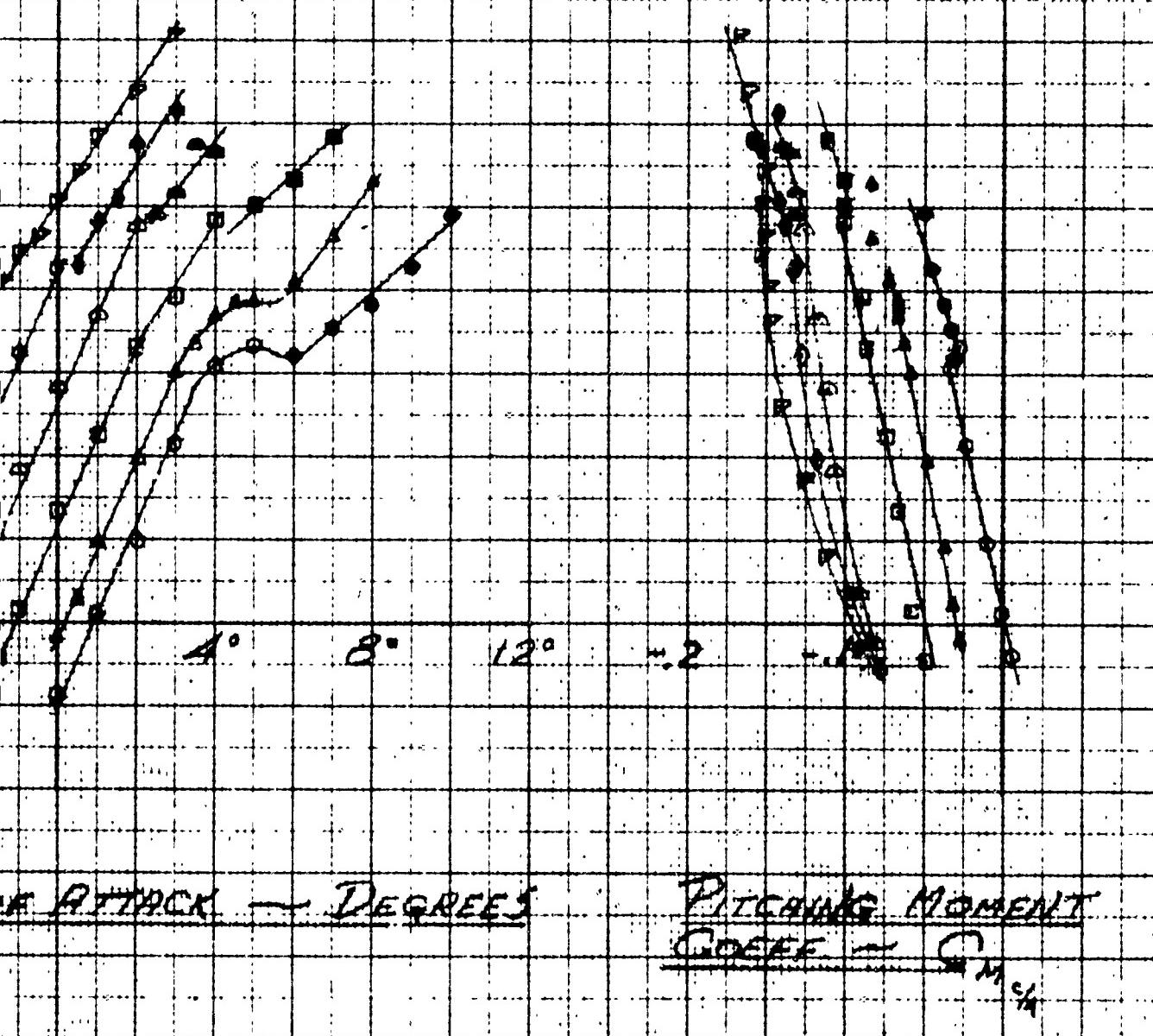
WHIRLING TANK TEST NO. 42

BUSHINGS FOIL NO. 13

MAC = .152 FT AREA = 89" D/C = 1.25

VEL = 60 KTS

TE
 DARKENED SYMBOLS
 INDICATE VENTED
 FLOW

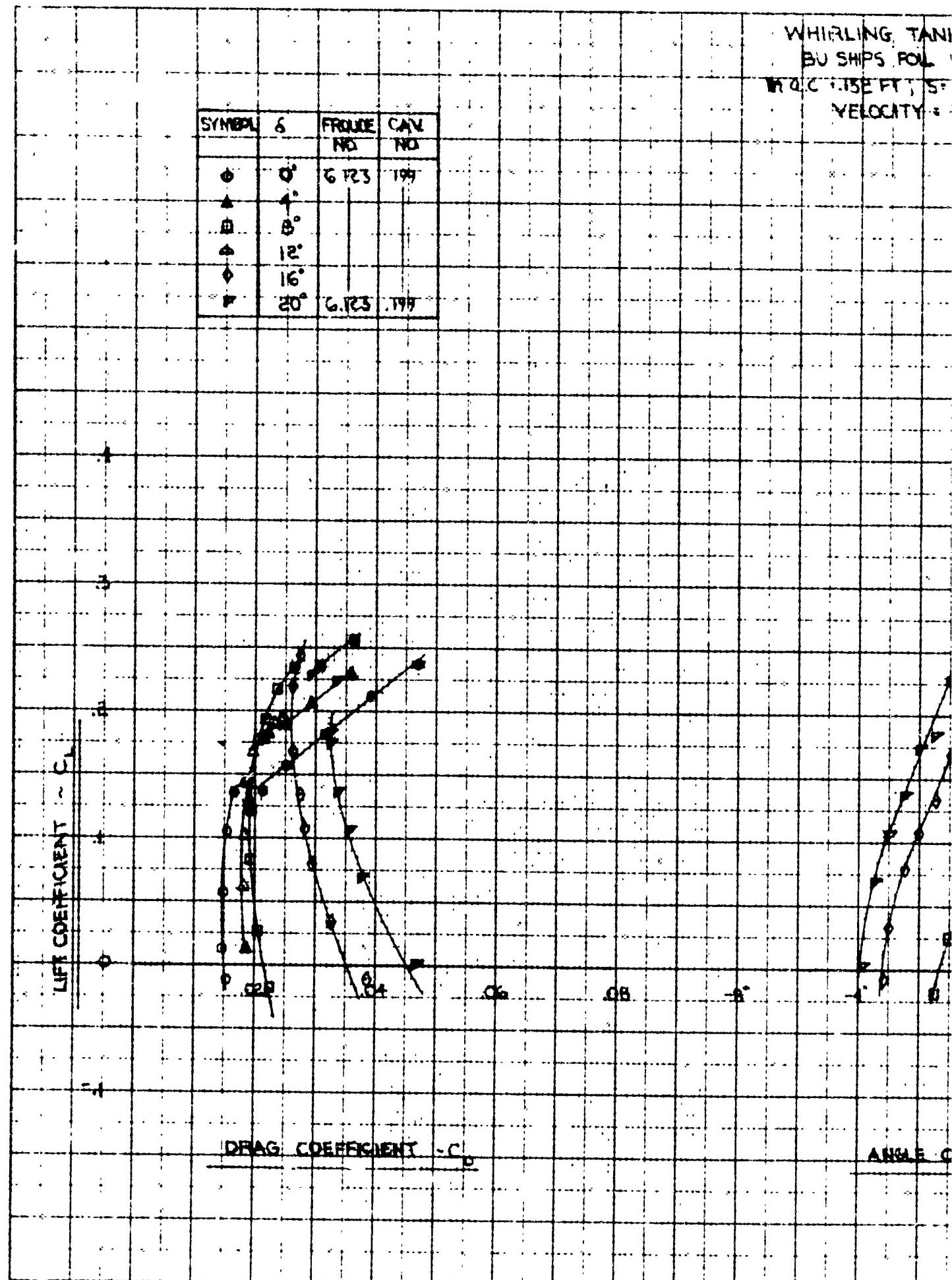


WHIRLING TANK
BU SHIPS POLL

IN 4 C : 15E FT; S.
VELOCITY =

SYMBOL	S	FROUDE NO	CAN NO
○	0°	6.123	199
▲	1°		
■	5°		
◆	12°		
◆	16°		
■	20°	6.123	199

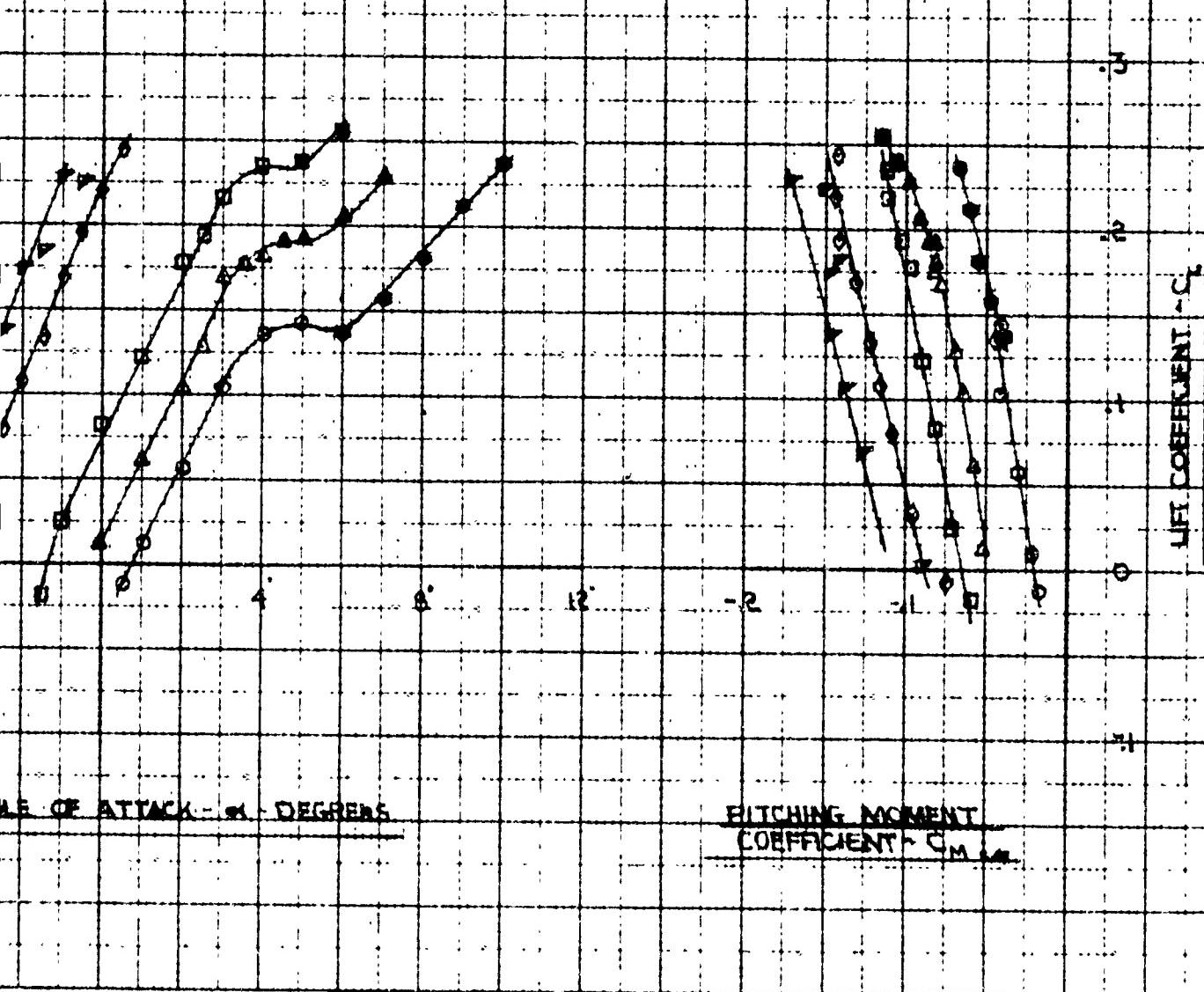
H&E alignment test 12/22/67



TANK TEST NO 42
TOL NO 13
S = 300 SQ IN A/D - .75
TY = 90 KTS

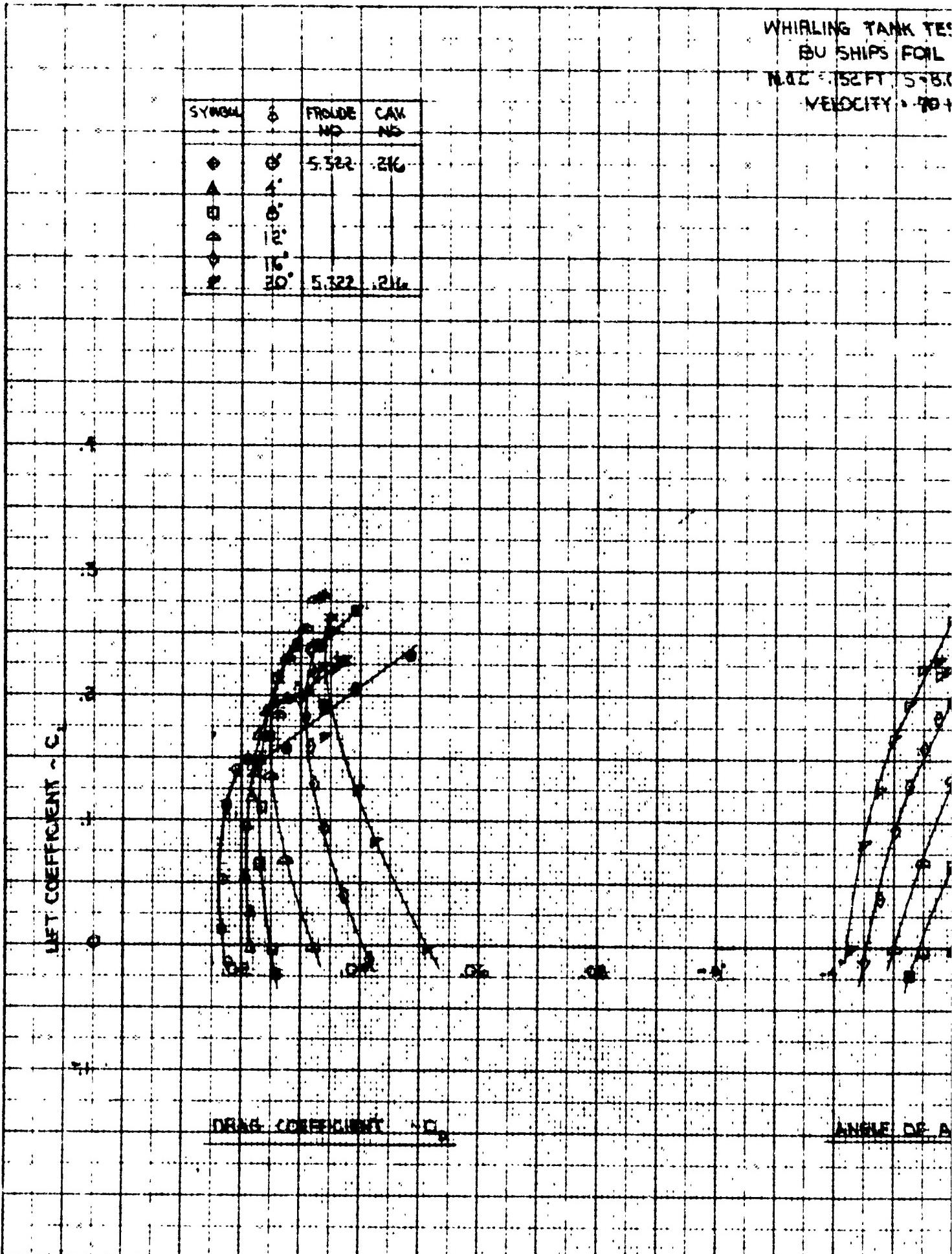
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NOTE: DARKENED POINTS INDICATE VENTED FLOW



WHIRLING TANK TEST
BU SHIPS FOIL
MAC = .752 FT 5-8X
VELOCITY = 70+

SYMBOL	ϕ	FROUDÉ NO	CAN NO
◆	0°	5.322	.216
▲	1°		
■	6°		
△	12°		
◆	18°		
◆	30°	5.322	.216



TEST NO 42

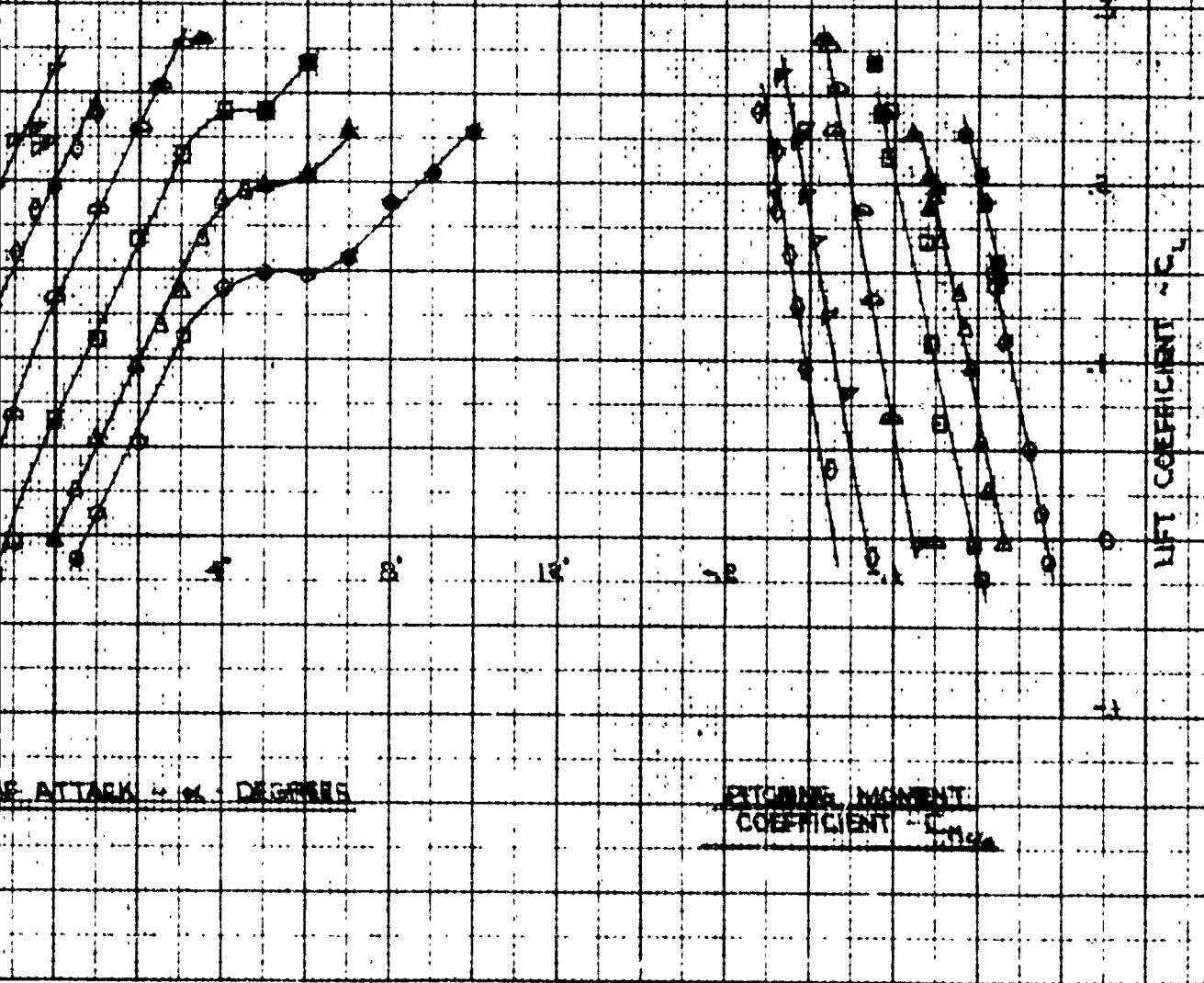
OIL NO 13

~8.00 SQ IN, dE=100

10 MTS

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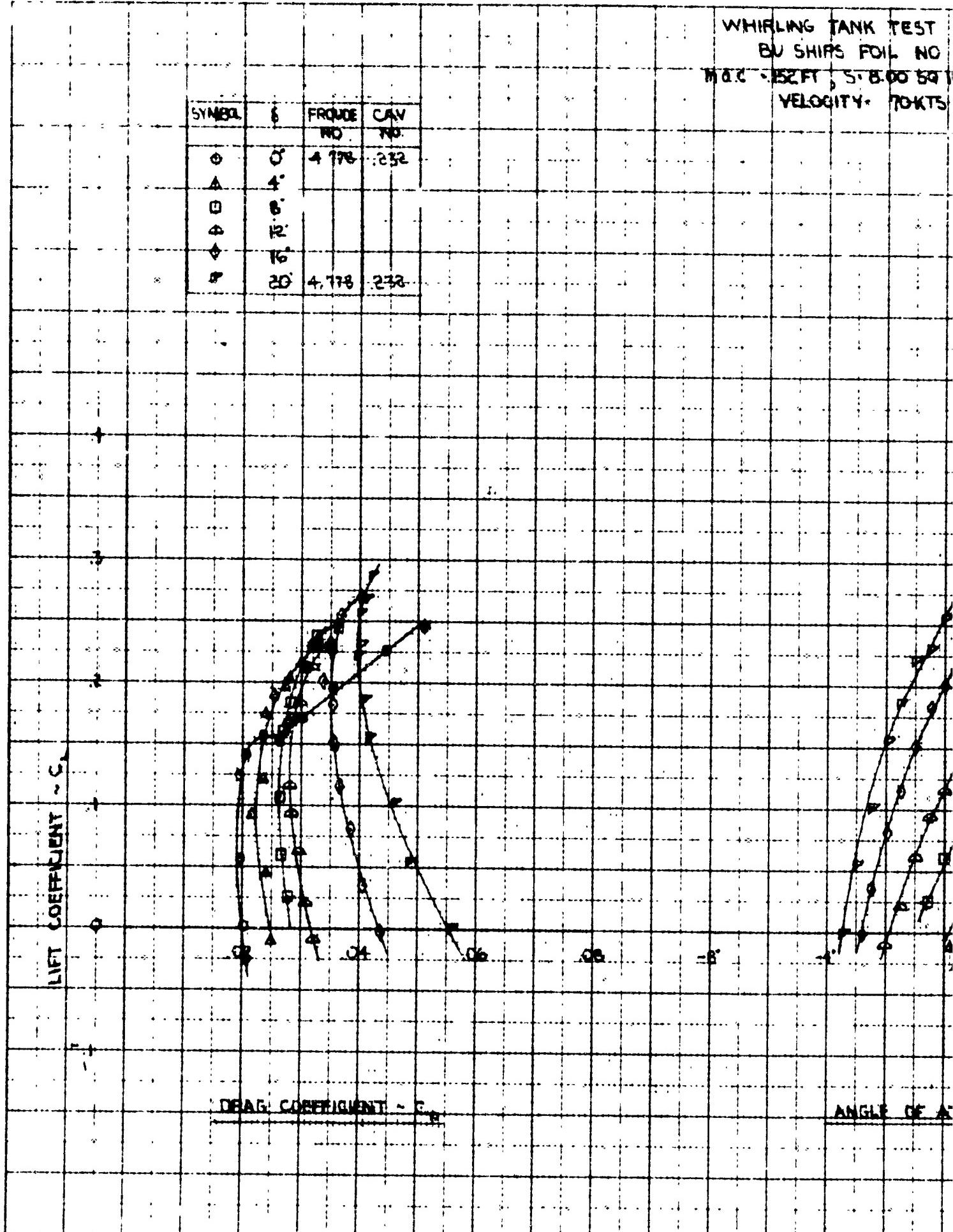
NOTE. DARKENED POINTS INDICATE VENTED FLOW



WHIRLING TANK TEST
BU SHIPS FOIL NO
M.O.C. - 152 FT, S. 8.00 SG
VELOCITY - 70 KTS

SYMBOL	FRONDE CAV NO.	FRONDE CAV NO.
○	0°	4.778
▲	4°	2.32
□	8°	
◆	12°	
◆	16°	
■	20°	4.778 2.32

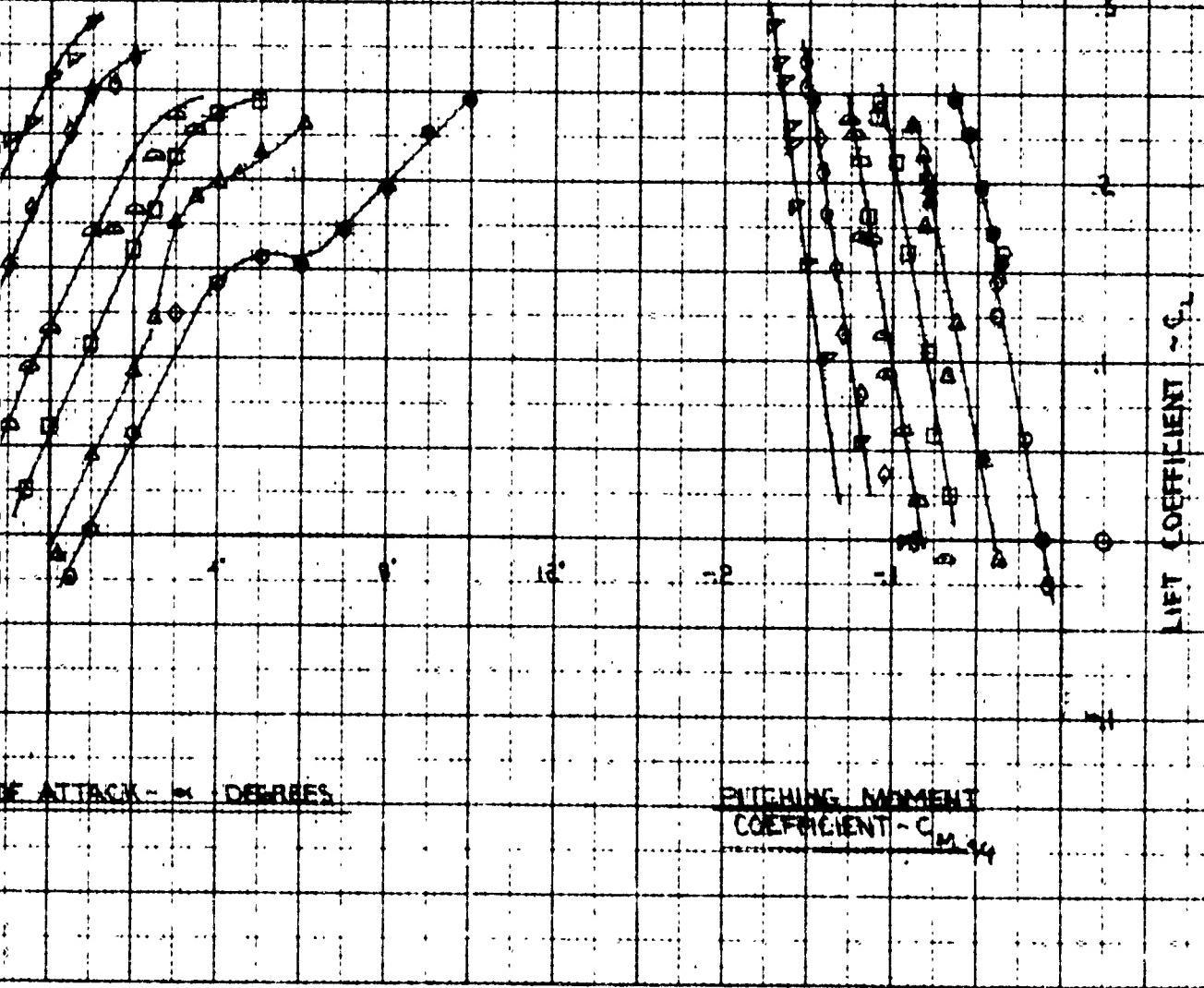
H.E. Alignment 1967



ST NO 42
NO 13
50 IN, d/c 1.25
KTS

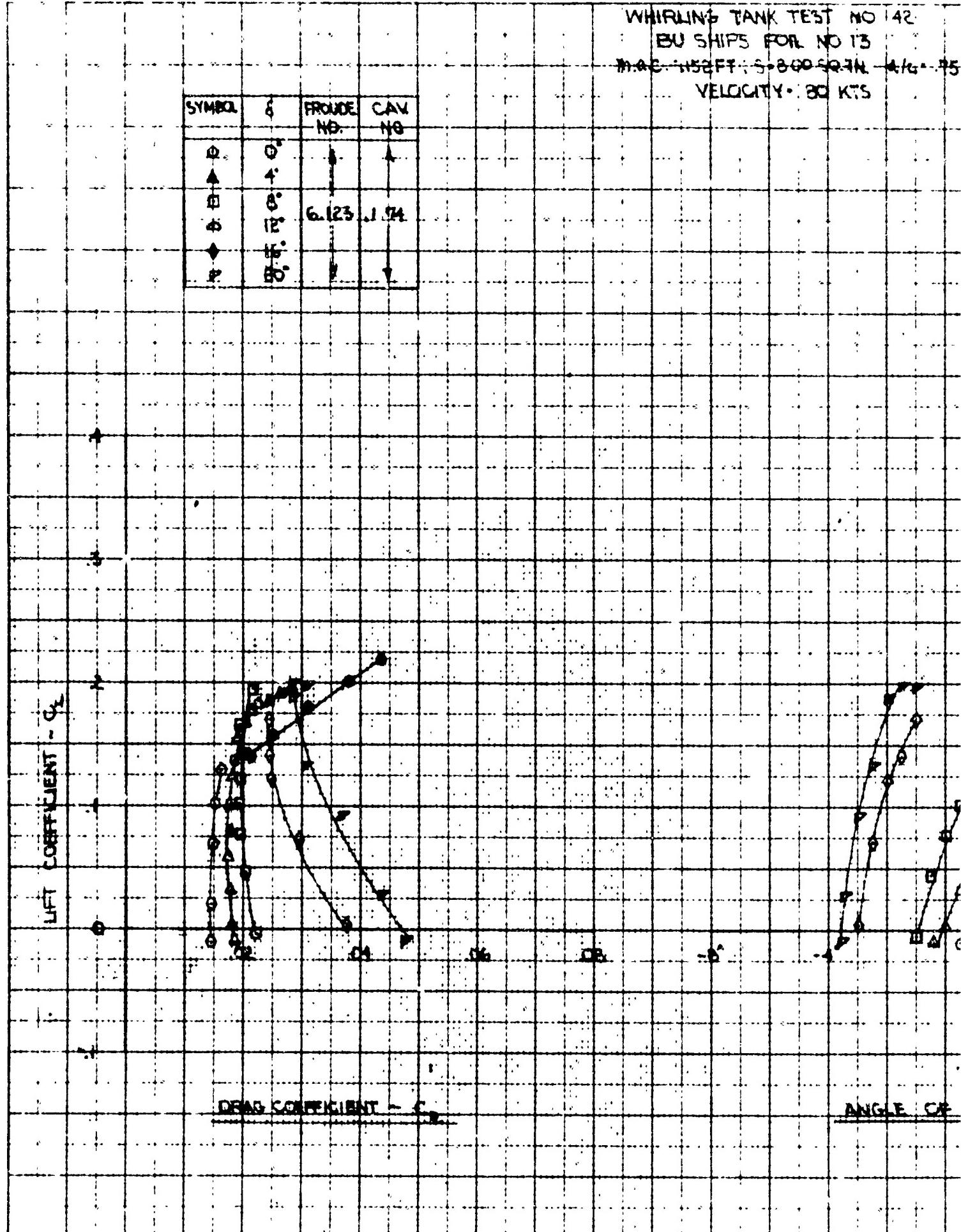
PAGE IV.133

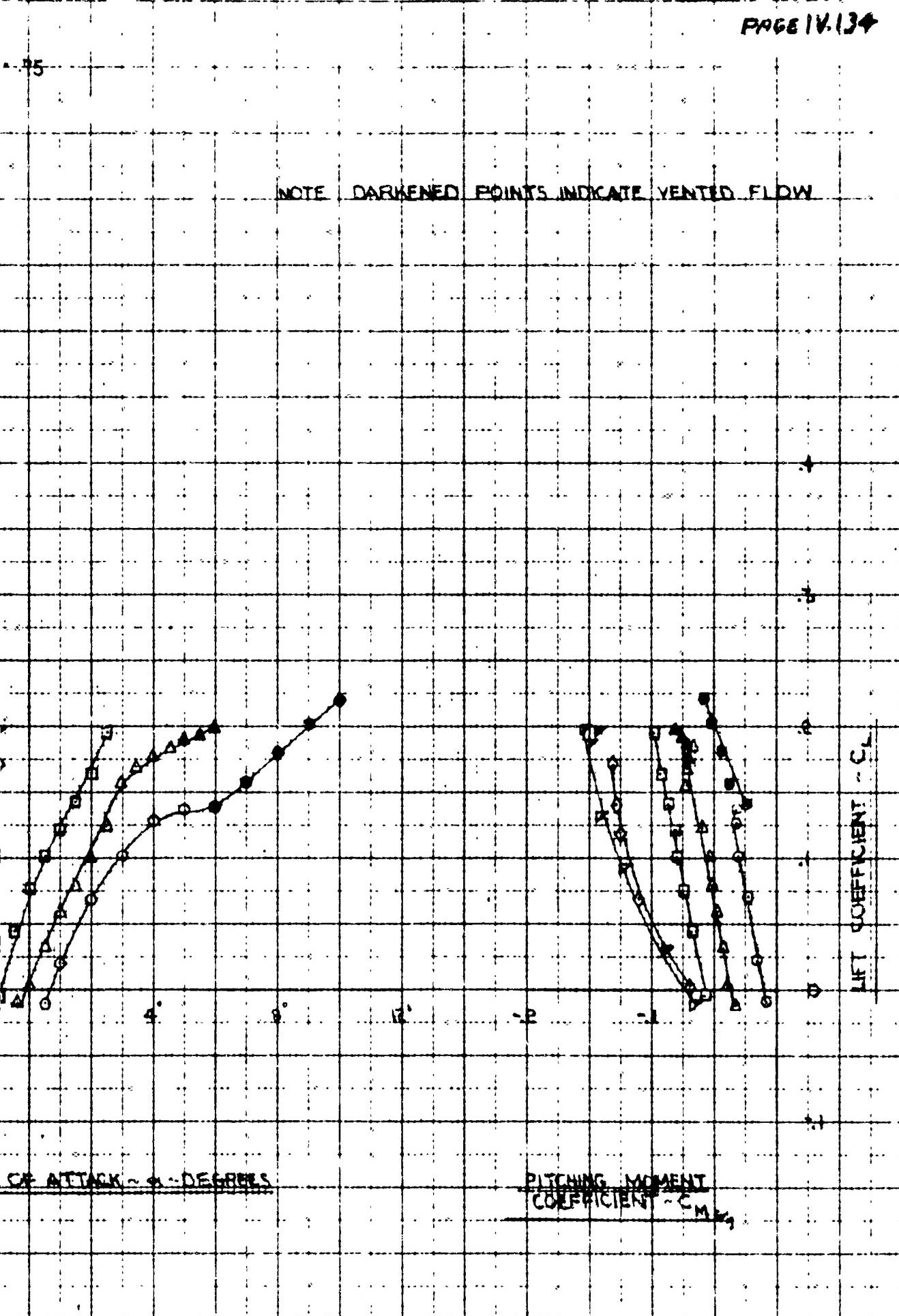
NOTE: DARKENED POINTS INDICATE VENTED FLOW



WHIRLING TANK TEST NO 142
BU SHIPS FOR NO 13
M.A.C. 1152 FT S. BOD. SQ. IN. 4145
VELOCITY 80 KTS

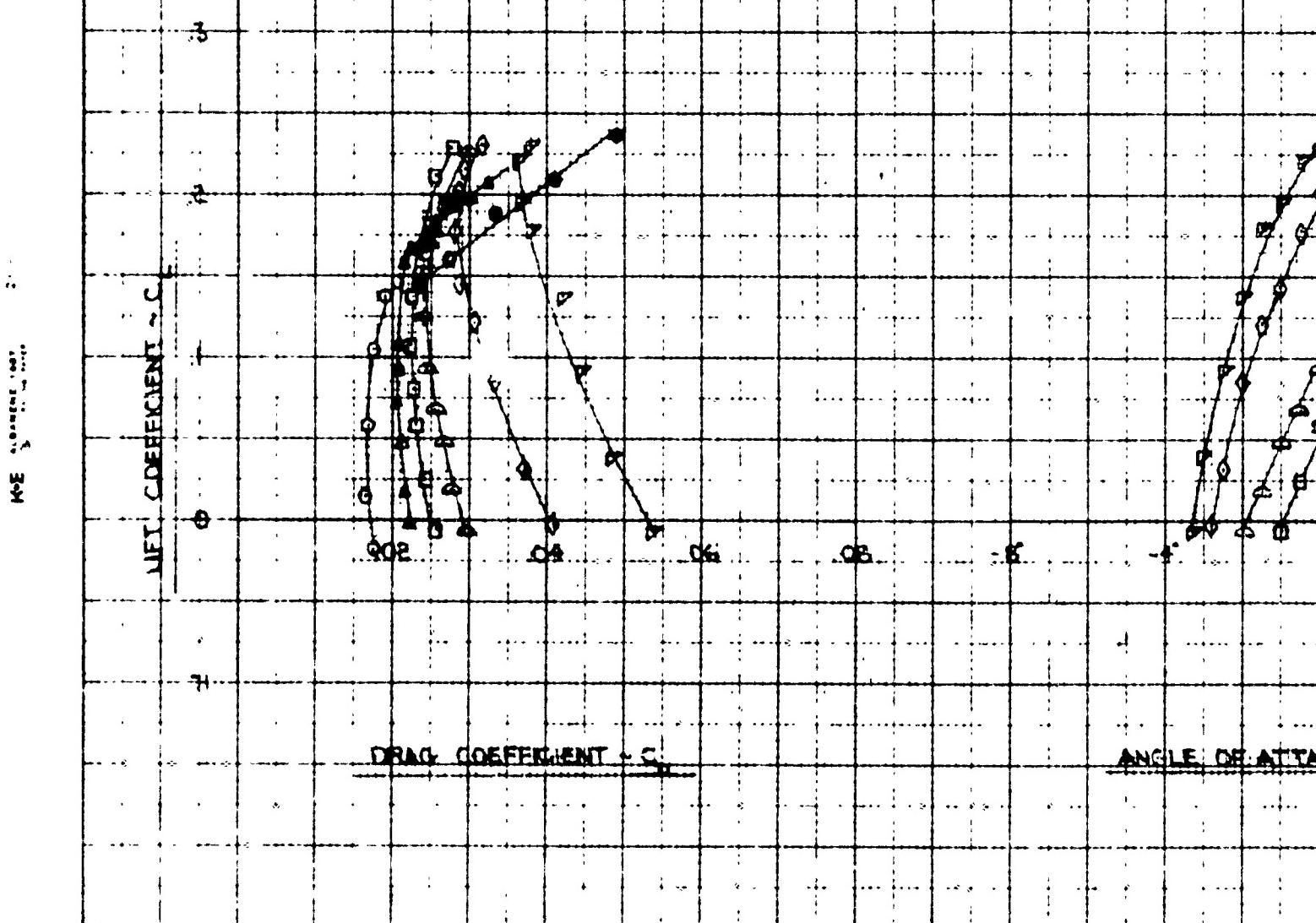
SYMBOL	6	FROUDE NO.	CAV. NO.
Φ	0°	-	+
▲	4°	-	+
■	8°	6.123	1.574
◆	12°	-	-
◆	16°	-	-
◆	20°	-	-





WHIRLING TANK TEST NO.
BU SHIPS FOIL NO 1
THICK. .152", \$ 8.00 SQ IN
VELOCITY 80 KTS

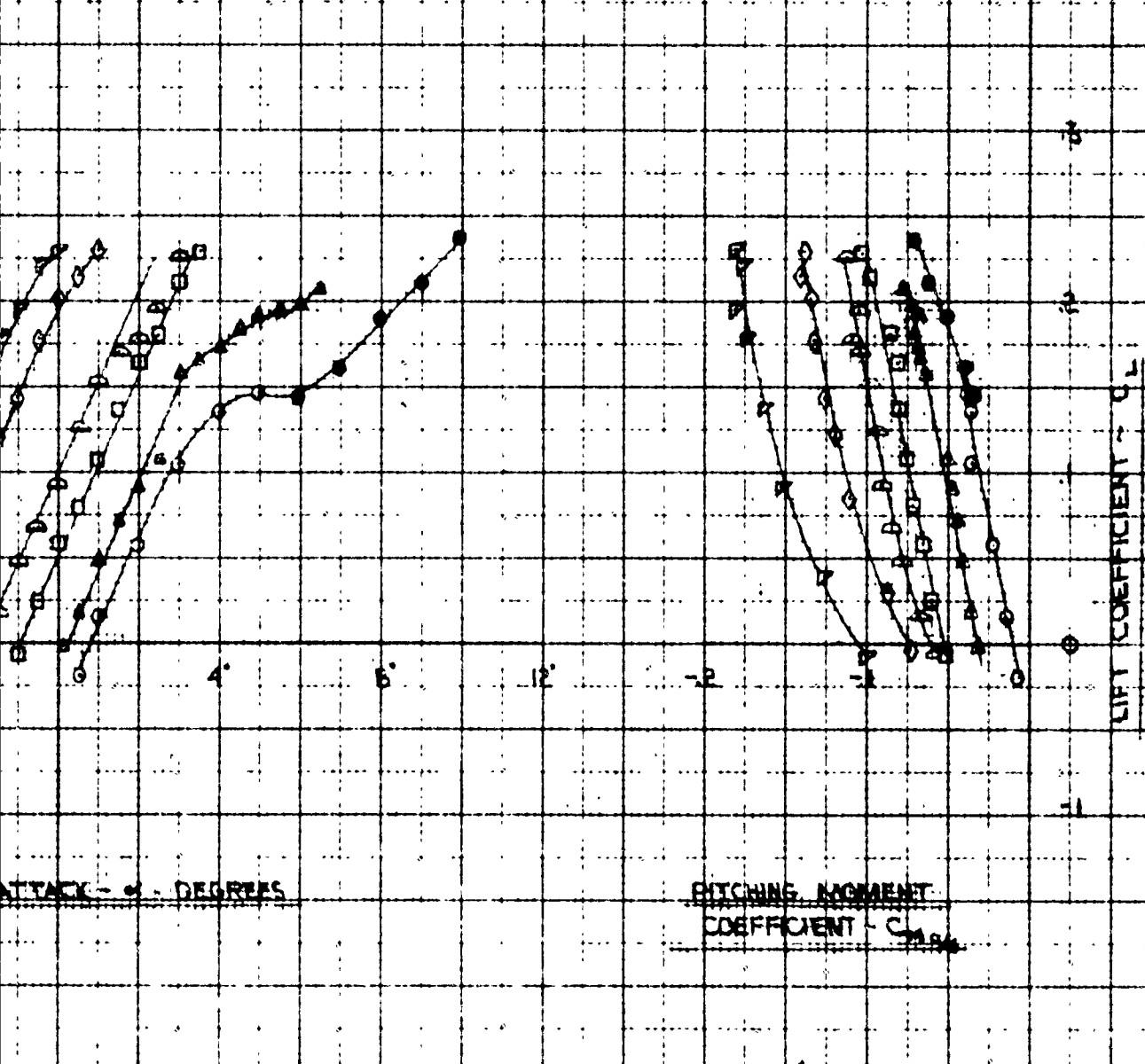
SYMBOL	6	FROUDE NO	CAN NO
6	6		
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6	6		
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T NO 42
NO 13
50 IN, 27C 7.00
KTS

PAGE IV.135

NOTE. DARKENED POINTS INDICATE VENTED FLOW



SYMBOL FLAP SET FROUDE NO. CAV. NO.

0° 0°
4° 4°
8° 7°
12° 8°
16° 5°
20° 9°

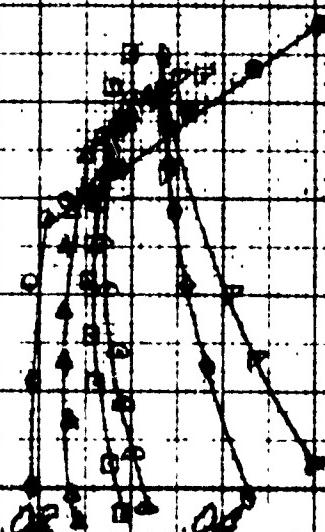
NOTE

1

.4

.3

C
-1
-2
-3
-4
-5



0.2 0.3 0.4 0.5 0.6 0.7

-0.1 -0.2 -0.3 -0.4 -0.5

-1

Drag Coeff ~ C_D

ANGLE OF A

WHIRLING TANK TEST NO 42

BUSHIPS FOIL NO. 13

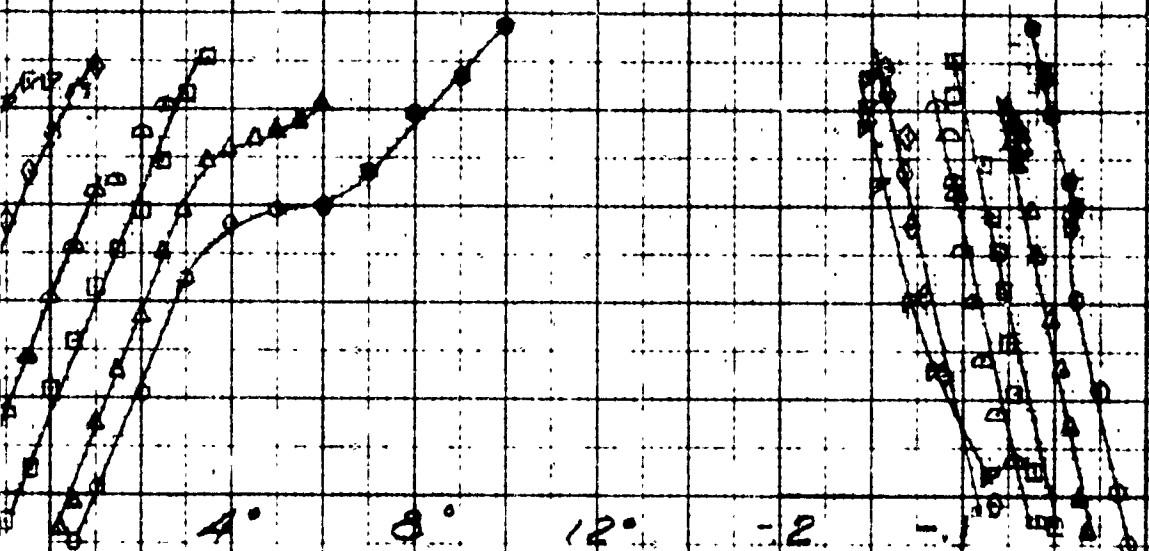
M.A.C. = 152 FT AREA = 850² % = 1.25

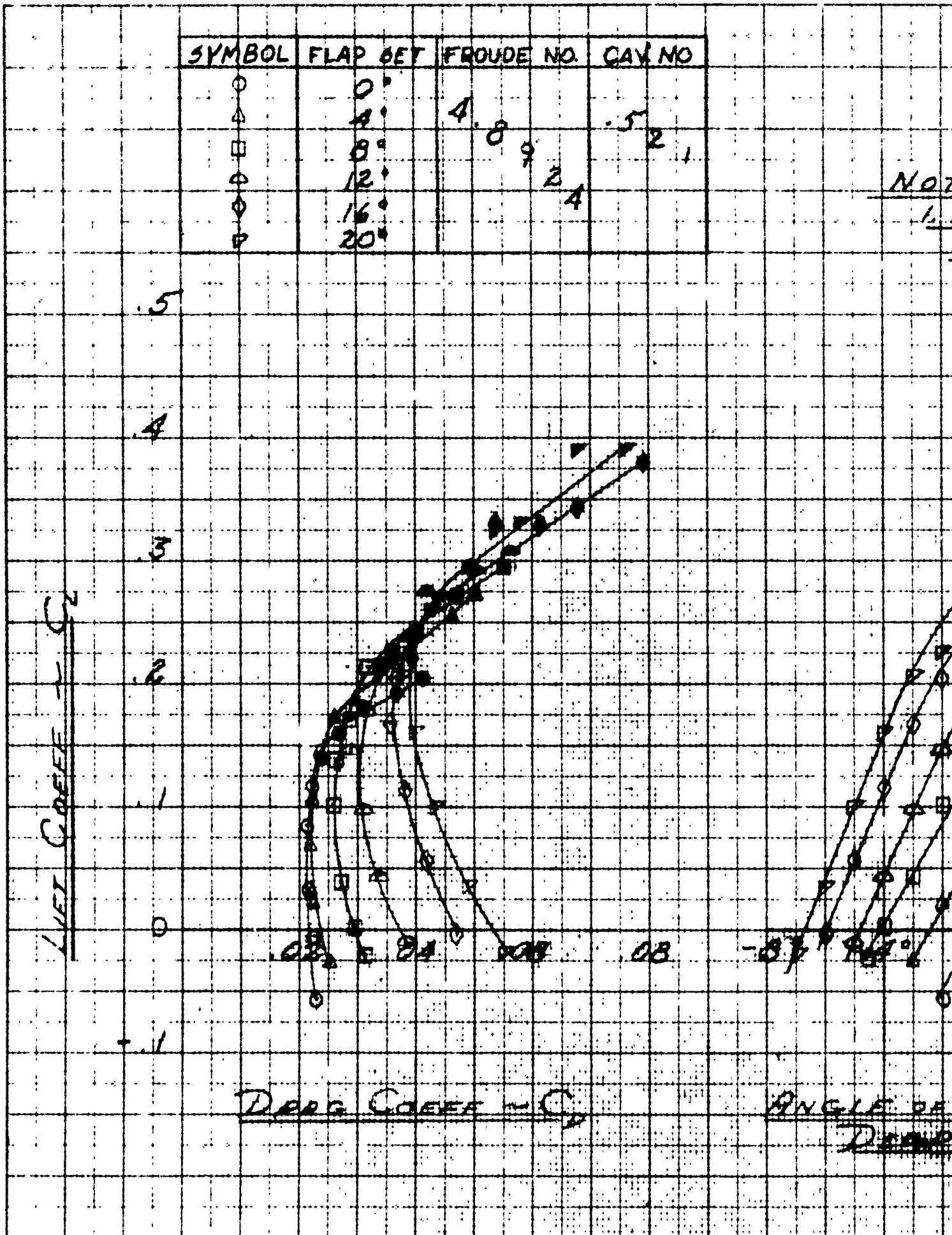
VEL = 30 KTS

TE:

1. DARKENED SYMBOLS
INDICATE VENTED
FLOW.

HE NUMBER 200

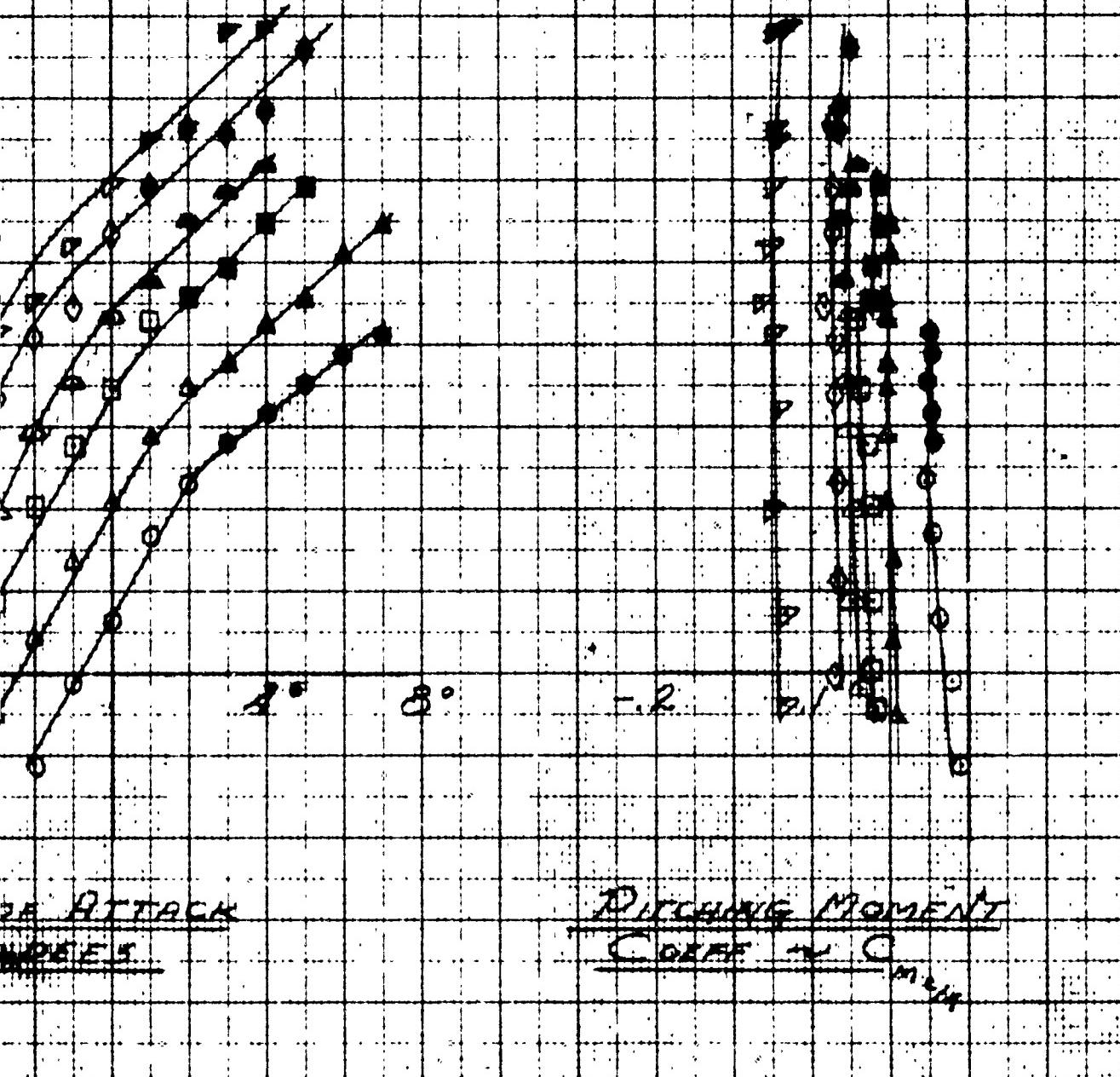




WHIRLING TANK TEST NO. 93
 BUSHNELL FOIL NO. 14
M.A.C. = 182 FT AREA = 80"
 $\frac{V}{C} = 1.00$
 $V = 40 \text{ KTS}$

OTE

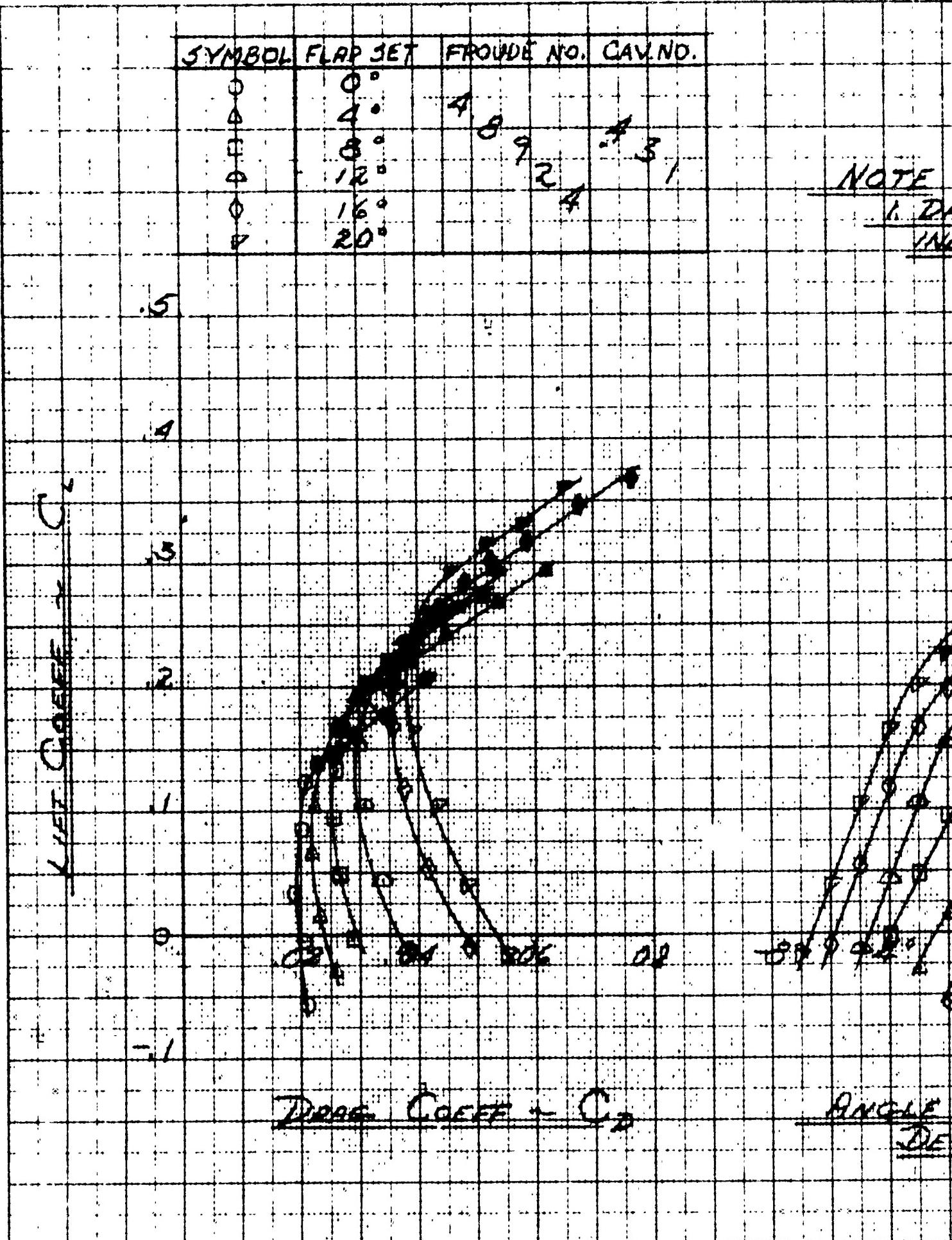
1. DARKENED SYMBOLS
 INDICATE VENTED FLOW.



ATTACK
DEGREES

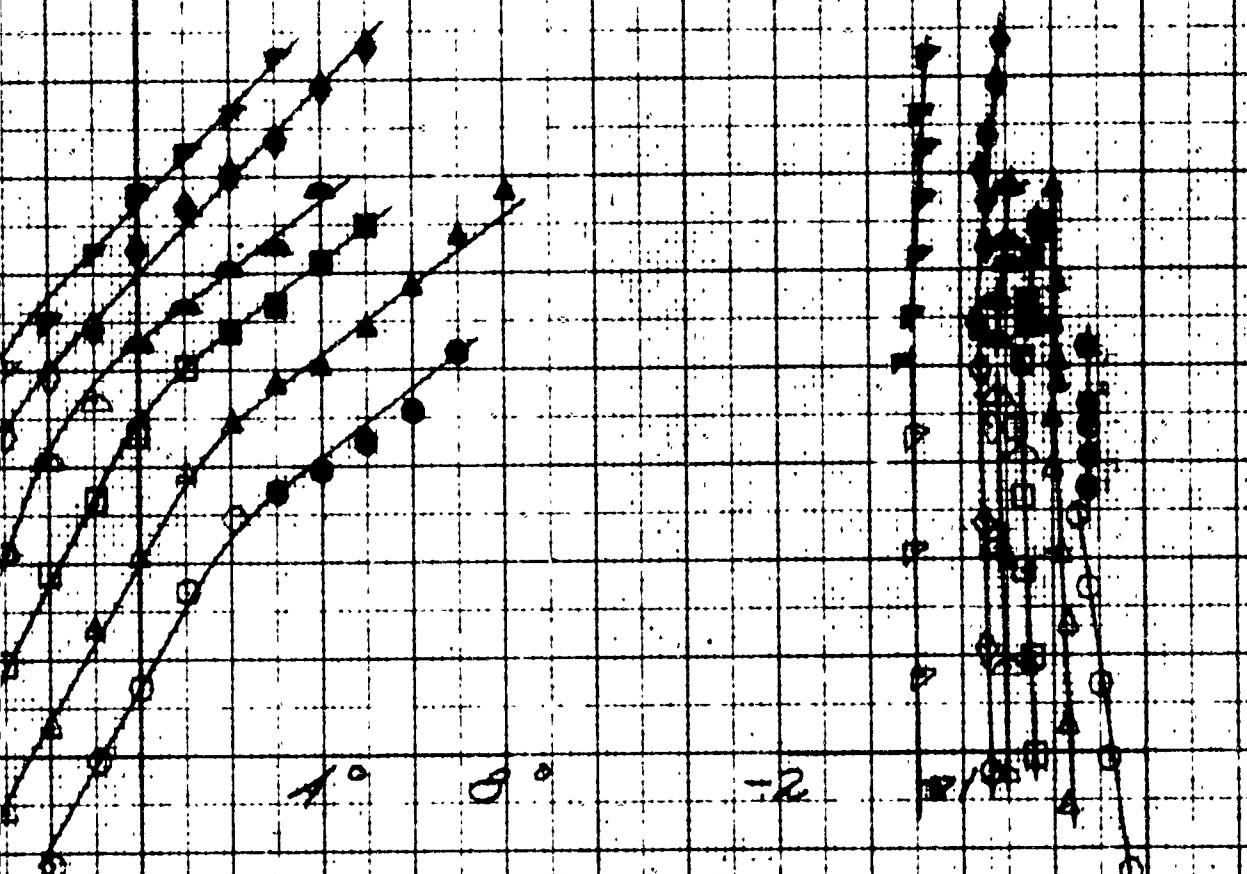
PITCHING MOMENT
COEFF - C_M

SYMBOL FLAP SET FROUDÉ NO. CAV NO.



WHIRLING TANK TEST NO 53
 BUSHIPS FOIL NO 18
 $MAC = 1.22 \text{ FT}$ $AREA = 30''^2$
 $\delta Y_a = 1.00$
 $VEI = 45 \text{ KTS}$

DARKENED SYMBOLS
 INDICATE VENTED FLOW



ANGLE OF ATTACK
 DEGREES

PITCHING MOMENT
 COEFF. = C_M

SYMBOL FLAP SET FROUDE NO. CAV. NO.

0°
4°
8°
12°
16°
20°

10° 9° 3°
2° 4° 6°

NOTE:

1. DARK
IND.

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WHIRLING TANK TEST NO. 43

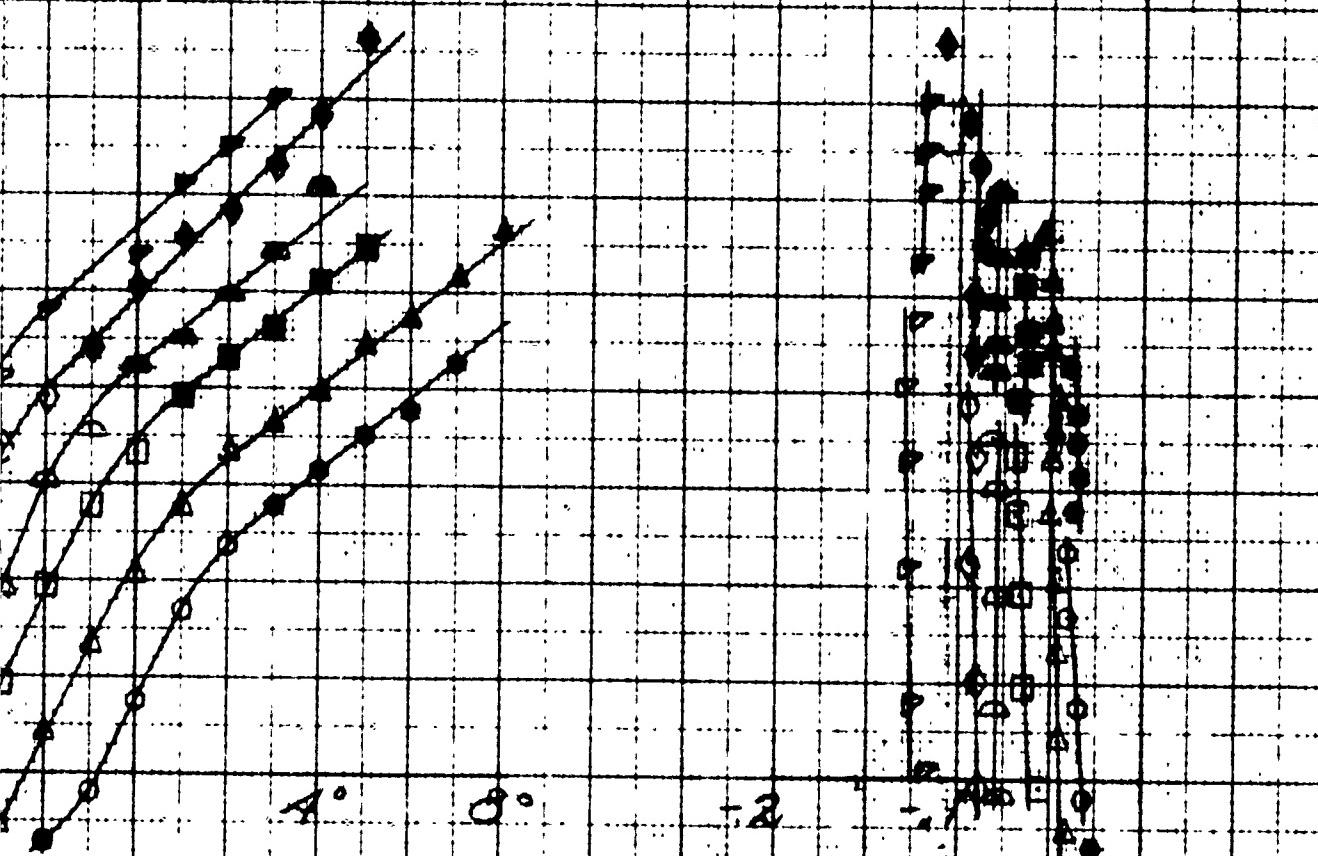
BUSHIPS FOIL NO. 14

M.A.C. = 18.2 FT AREA = 30"

$$C = 1.00$$

$$\sqrt{C} = 50 \text{ KTS}$$

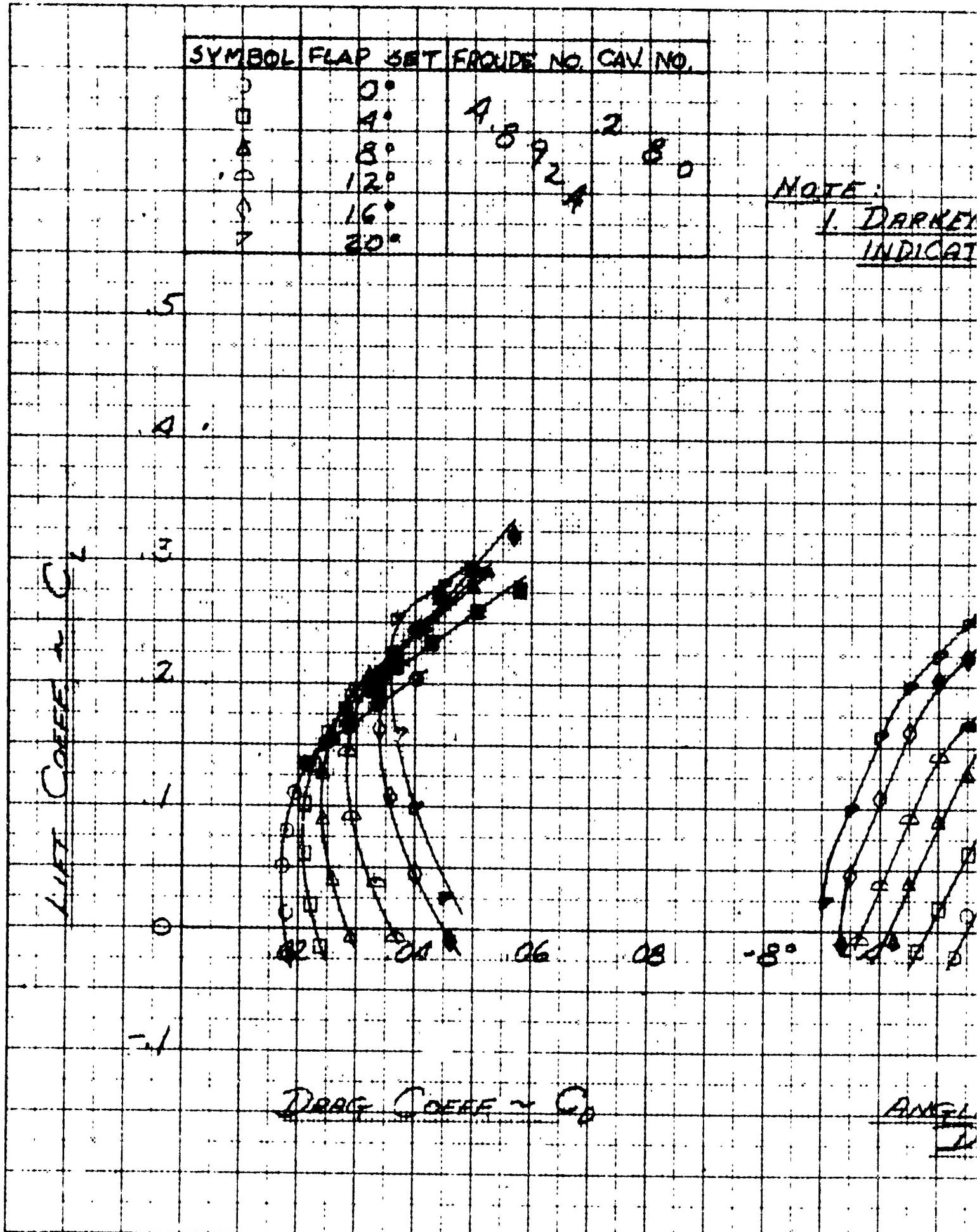
MARKED SYMBOLS
INDICATE VENTED FLOW.



ANGLE OF ATTACK
DEGREES

PITCHING MOMENT
COEFF. $\times 10^4$

SYMBOL FLAP SET FROM DE NO CAV NO.



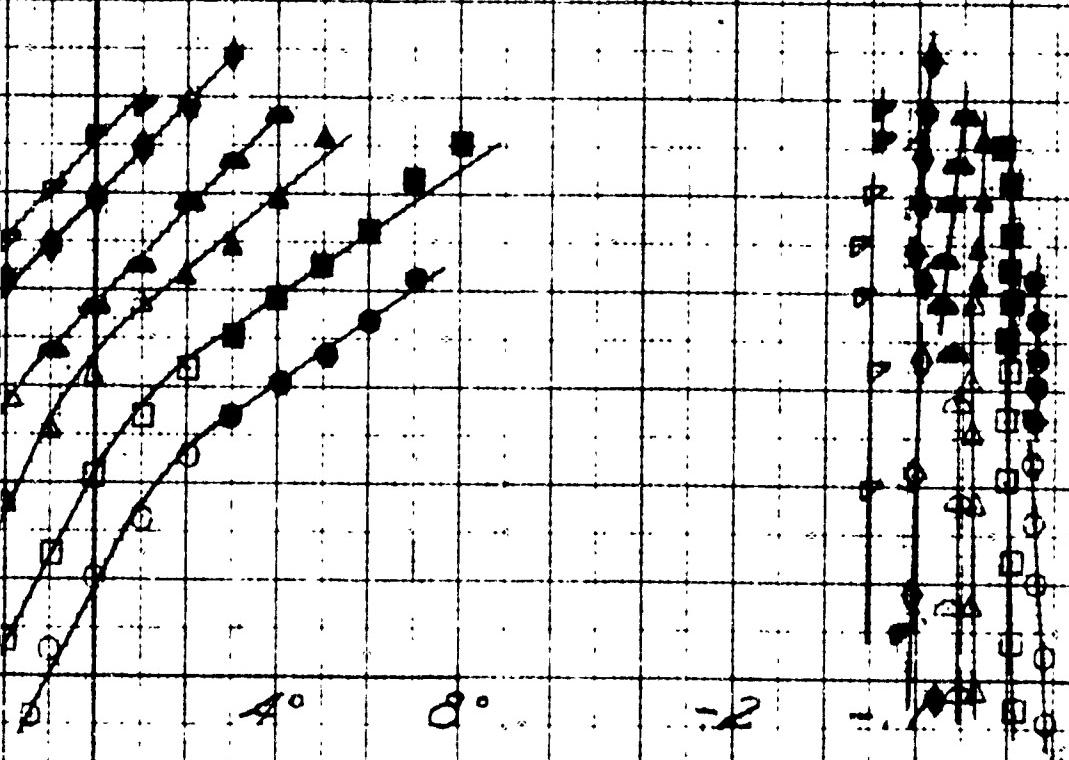
PAGE IV.140

WHIRLING TANK TEST NO. A3
BU SHIRE FORK NO. 1A
V.L.H.C = 182 FT. PRESS 380"

$$\gamma_c = 1.00$$

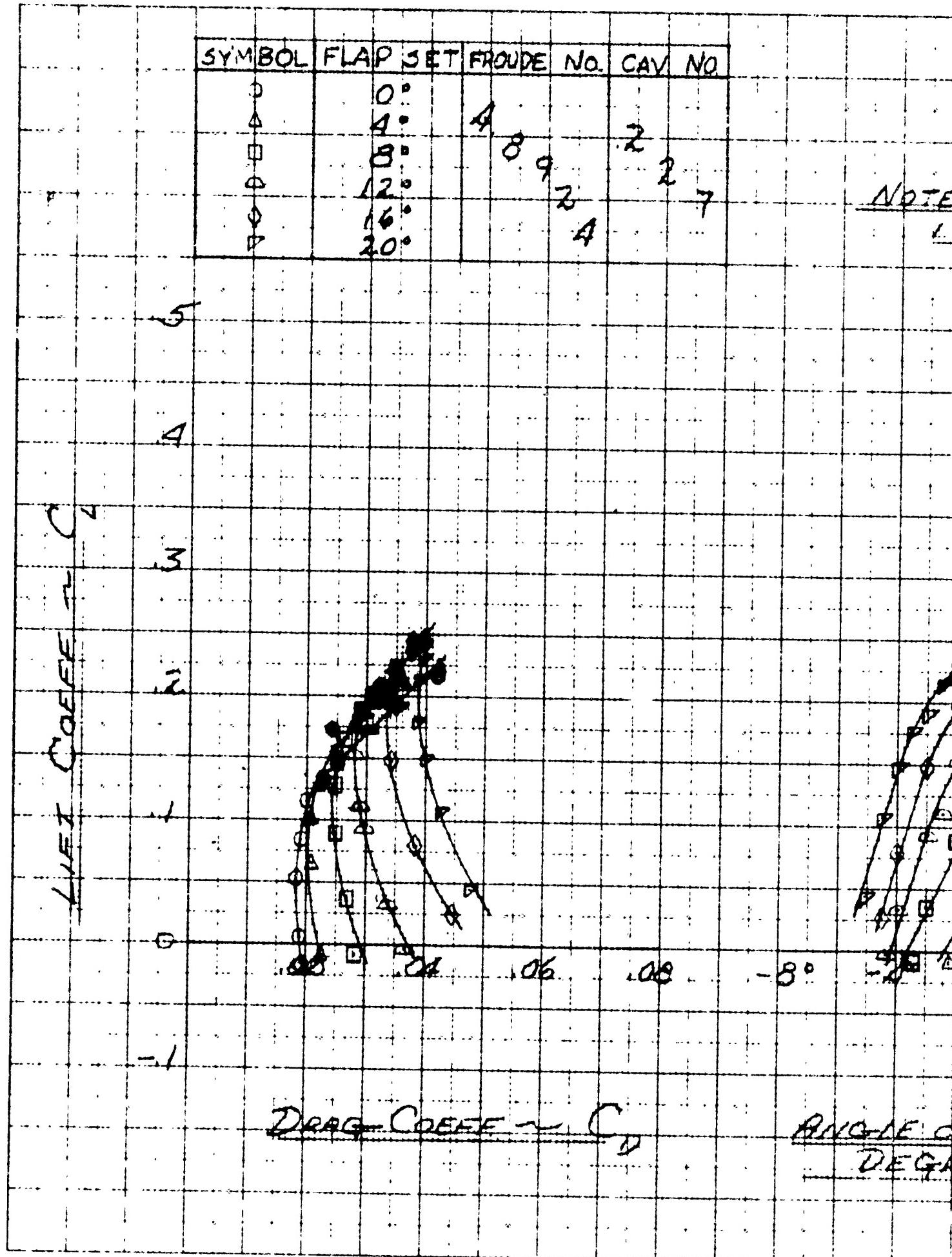
$$U = 60 \text{ KTS}$$

KEYED SYMBOLS
RATE VENTED FLOW



ANGLE OF ATTACK
DEGREES

PITCHING MOMENT
COEFF ~ C_M_α



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WHIRLING TANK TEST NO. 13

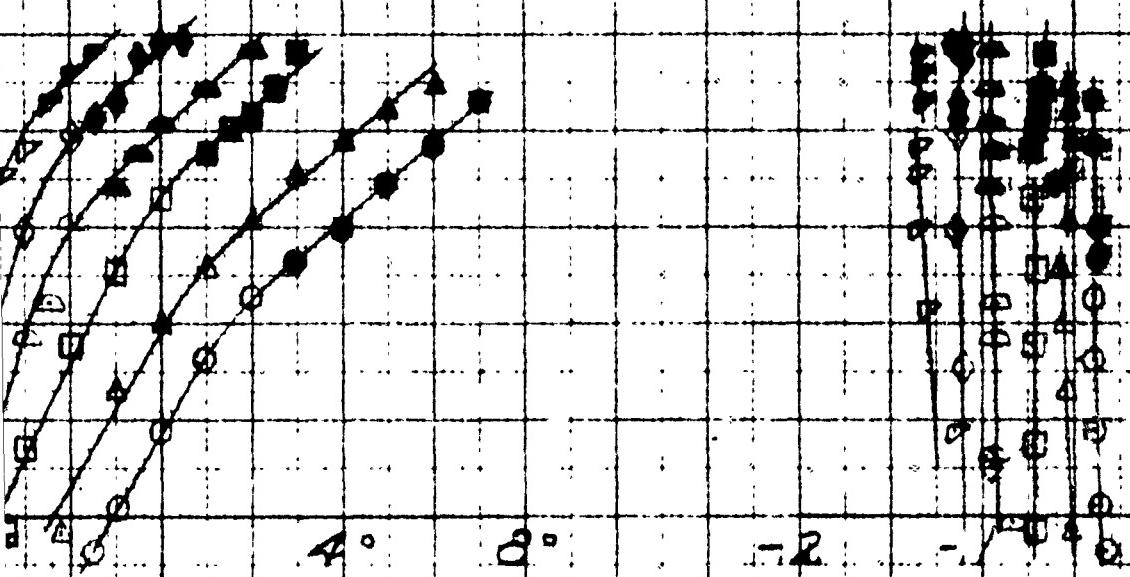
BUSHNELL FOIL NO. 14

M.A.C. = 182 FT. AREA = 80"

D/C = 1.00

= 70 KTS

1 DARKENED SYMBOLS
INDICATE VENTED FLOW



CF ATTACK
GEE'S

PITCHING MOMENT
COEFF + C_y
1/54

SYMBOL FLAP SET FROUDE NO. CAV NO.

0°	4°	7.8	1
4°	8°	9	9
8°	12°	2	1
12°	16°	4	
16°	20°		

NOTE:
1. DAR
IND

LIET COFFEE + C

2

3

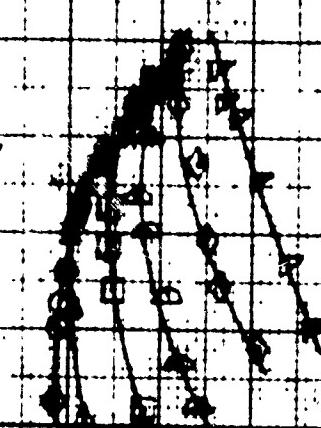
5

4

1

0

-1



02 04 06 08 10° - 4°

Deep Coffee w C

Parade o
PEG

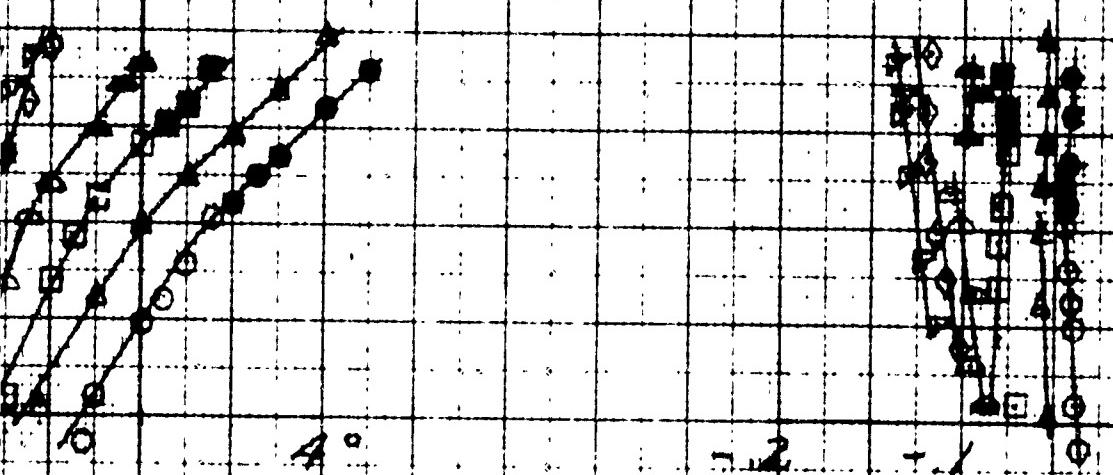
WHIRLING TANK TEST NO 43
BUSHIPS FOIL NO. 19
MAC = .182 FT AREA = 3.01

$$\frac{V}{C} = 1.00$$

$$V = 80 \text{ KTS}$$

DARKENED SYMBOLS

INDICATE VENTED FLOW.



ANGLE OF ATTACK
IN DEGREES

PITCHING MOMENT
COEFF - CM

SYMBOL FLAP SET FROUD & CAV. NO

0° 4° 8° 12° 16° 20°

5 3 2 1

NOTE

1 DARKENED
INDICATE

4
3
2
1
LET COEFF = C_D

DATA COEFF = C_D

ANGLE OF
DEG-DEG

PAGE 1443

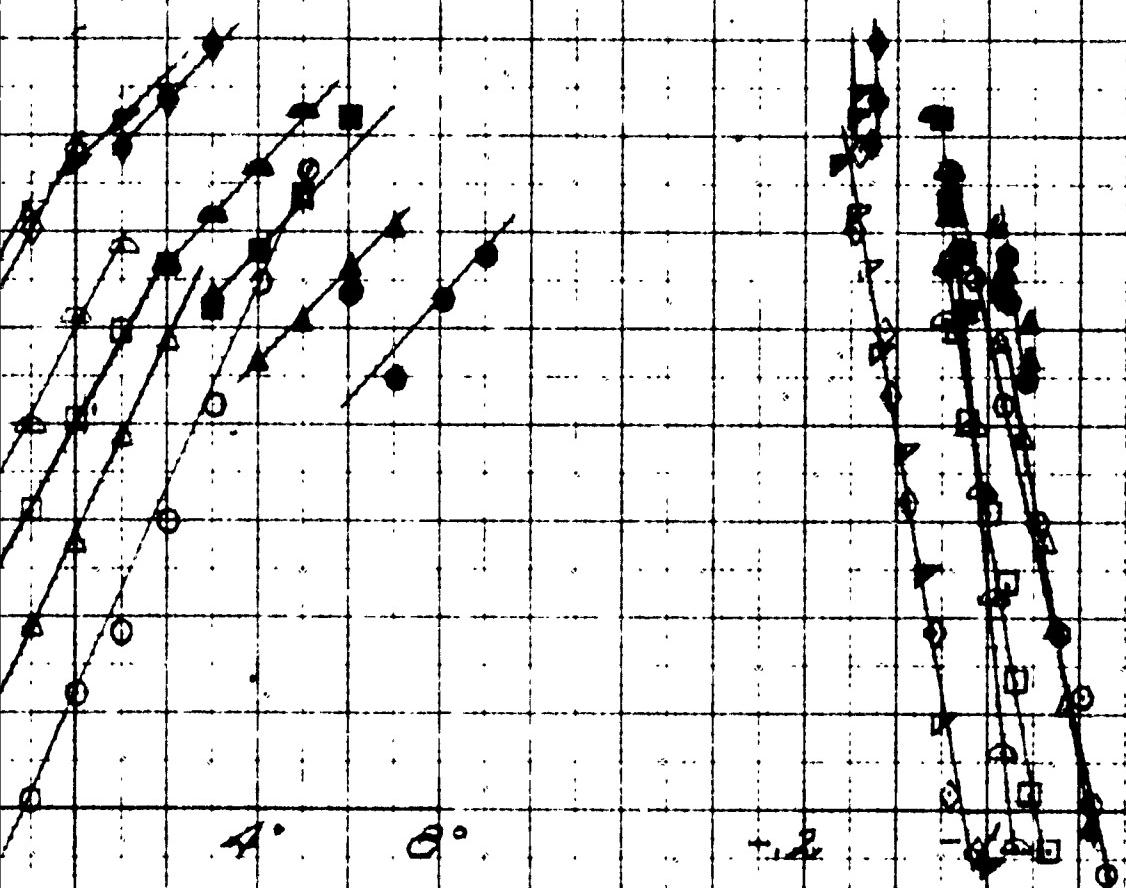
WATER TANK TEST NO. 50

BUSHINGS FOR NO. 15

M.D.C. = 152 FT. AREA = 80"

$\rho/c = 1.00$ $V = 90 \text{ KTS}$

ENED SYMBOLS
ATE VENTED FLOW



ANGLE OF ATTACK
DEGS.

PITCHING MOMENT
COEFF. ~ C_M

SYMBOL FLAP SET FROUDE NO CAV NO

0 0°

1 1°

2 2°

3 3°

4 4°

5 5°

6 6°

7 7°

8 8°

9 9°

10 10°

11 11°

12 12°

13 13°

14 14°

15 15°

16 16°

17 17°

18 18°

19 19°

20 20°

NOTE:

1 DARKENED 5
INDICATE KARV

15

4

3

2

C 2 COEFF

0

-1

Deep Coeff - C_D

ANGLE OF A
DEGREE

PAGE M14

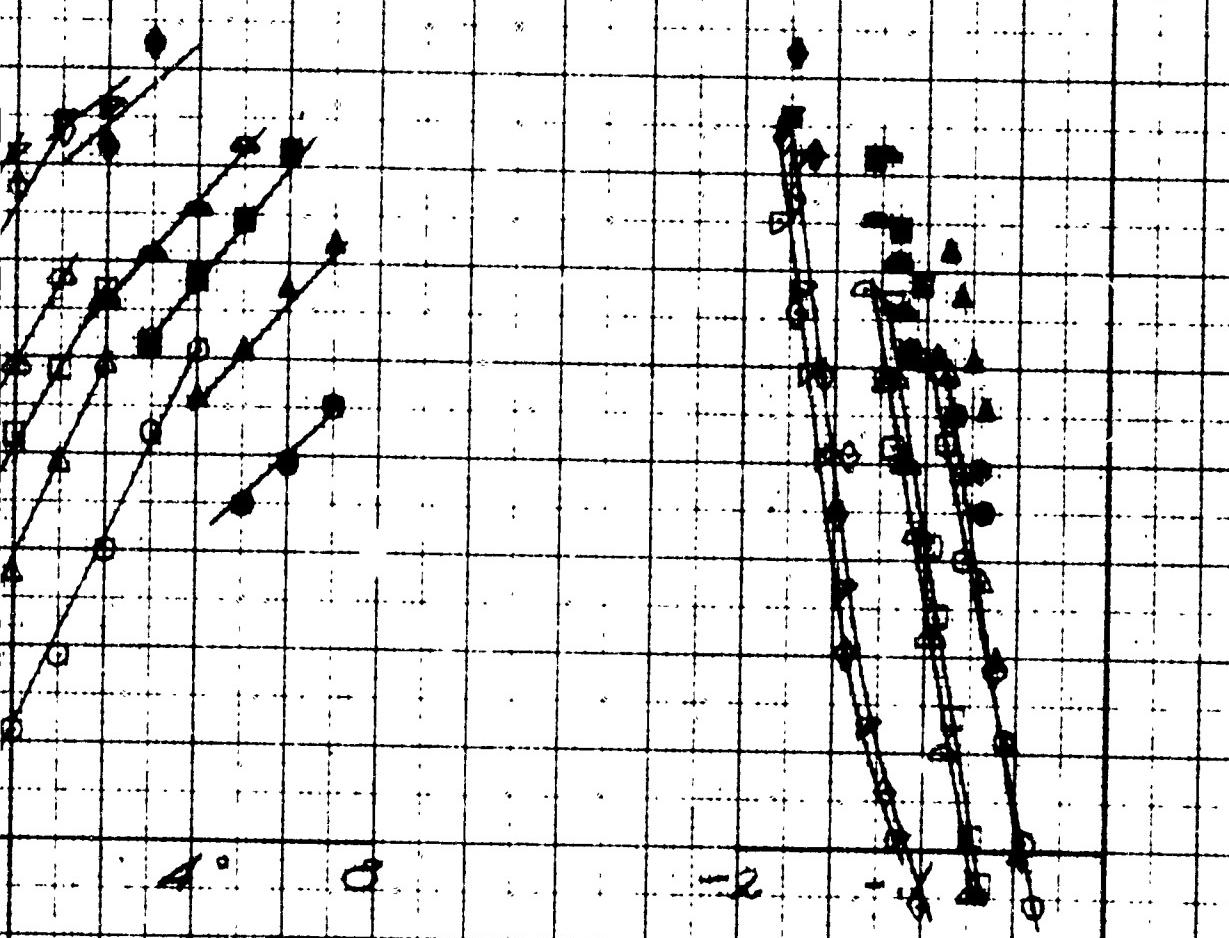
WATER TANK TEST NO. 4

BUSHIPS FOIL NO. 15

M.P.C. = 152 FT. SPAN = 8.0'

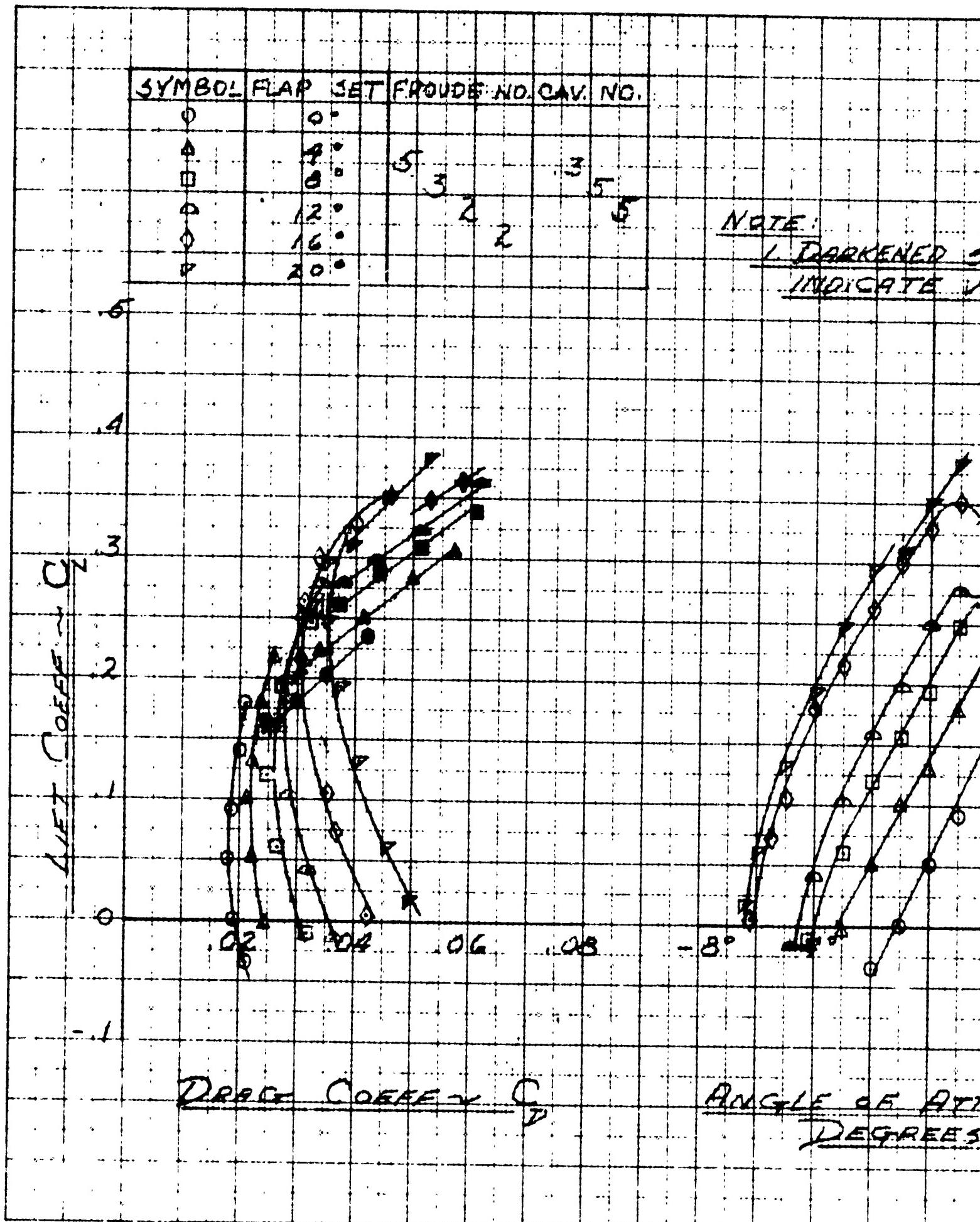
C/C = 1.00. V = 45 KTS.

SYMBOLS
REVVED FLOW.



ATTACK
SES

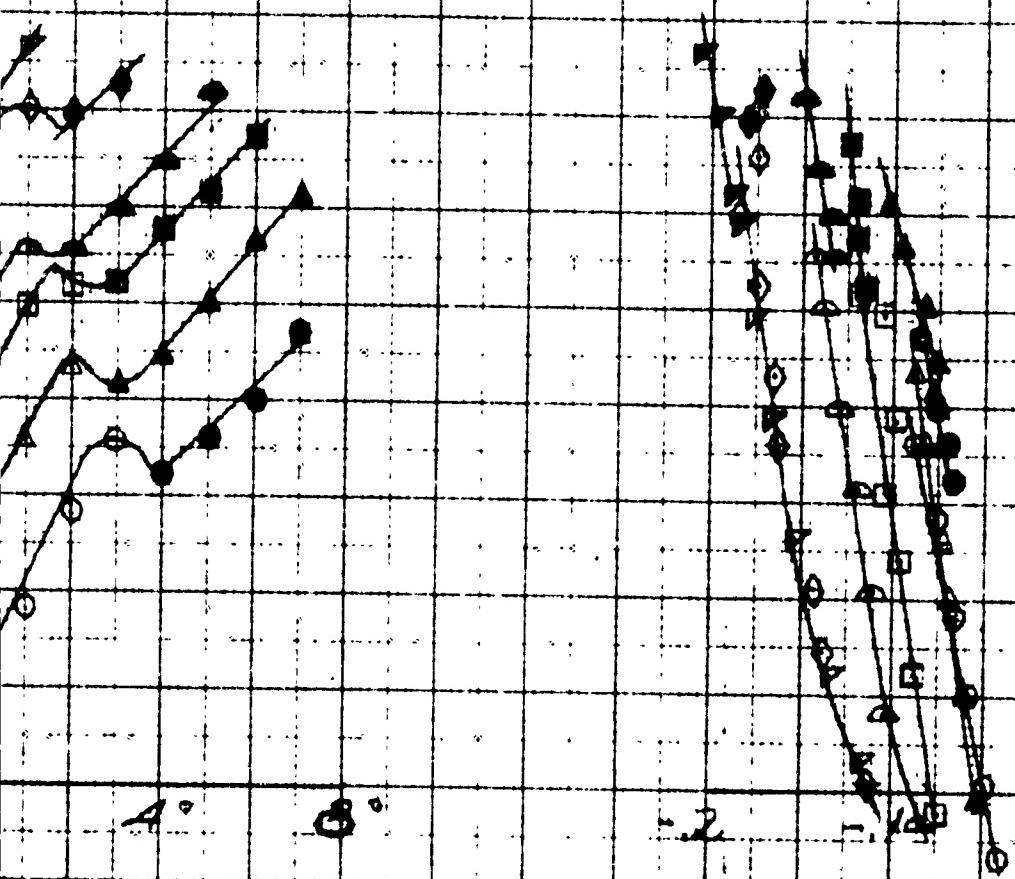
PITCHING MOMENT
 $C_{M,0} \approx 0$



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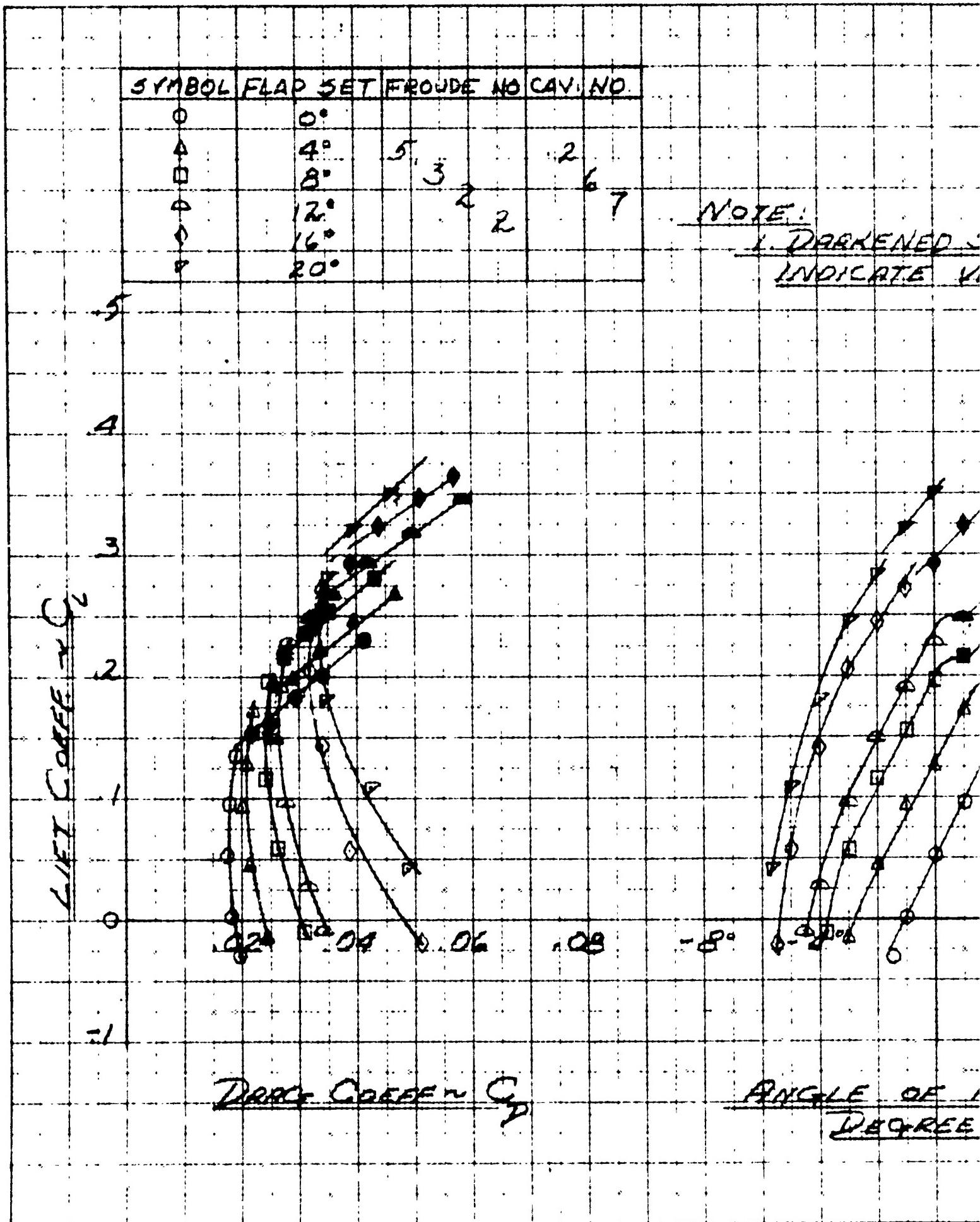
WHIRLING TANK TEST NO 538
BU SHIAS FOIL NO 15
 $MAC = .152 \text{ FT}$ $AREA = 8.00 \text{ FT}^2$
 $a/c = 1.00$ $V = 50 \text{ KTS}$

SYMBOLS
VENTED FLOW.



ATTACK
ES

WHIRLING MOMENT
COEFF. ~ $C_{M_{04}}$



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WHIRLING TANK TEST NO. 44

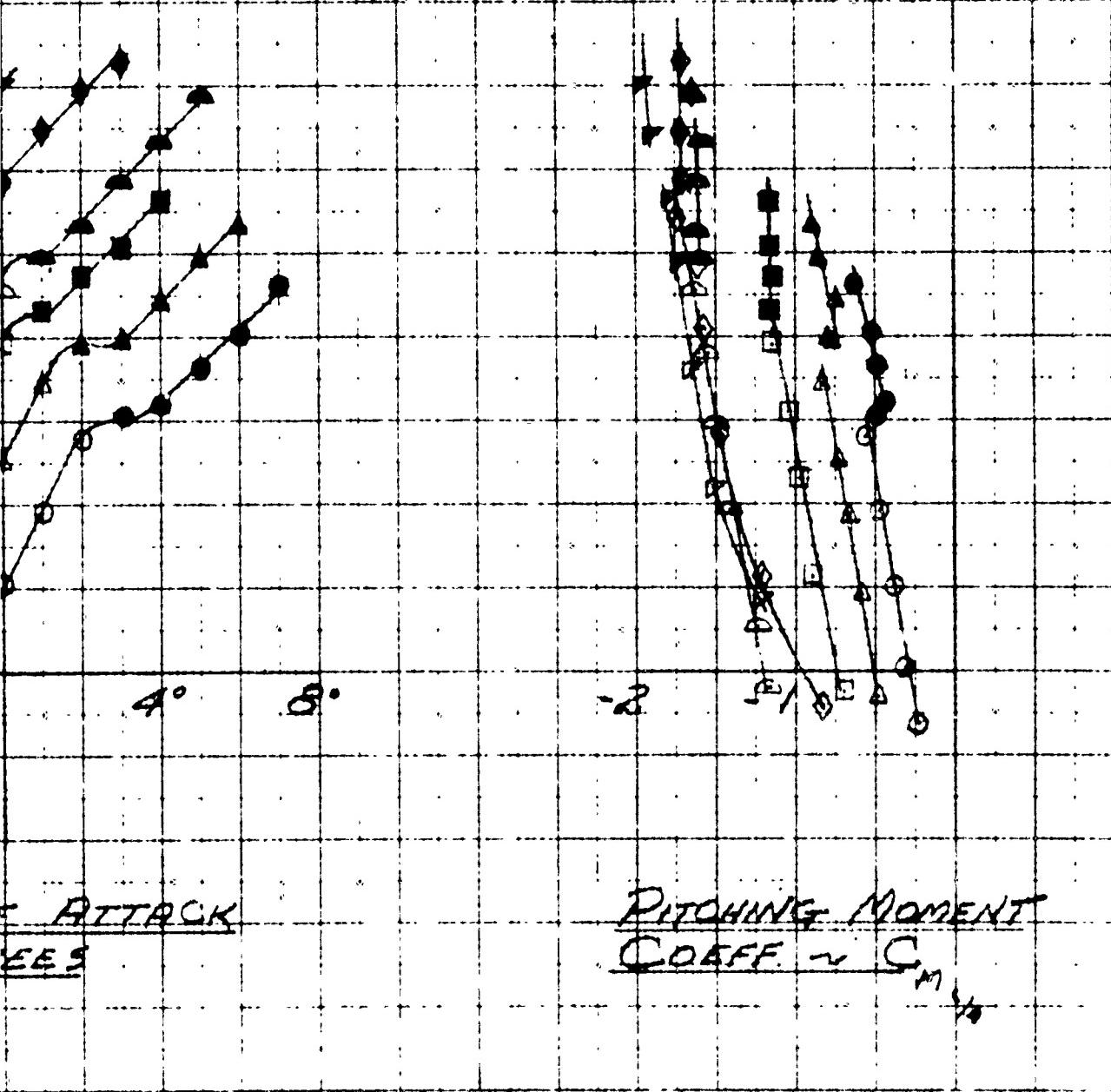
BUSHIPS FOIL NO. 15

M.A.C. = .152 FT AREA = 8.7

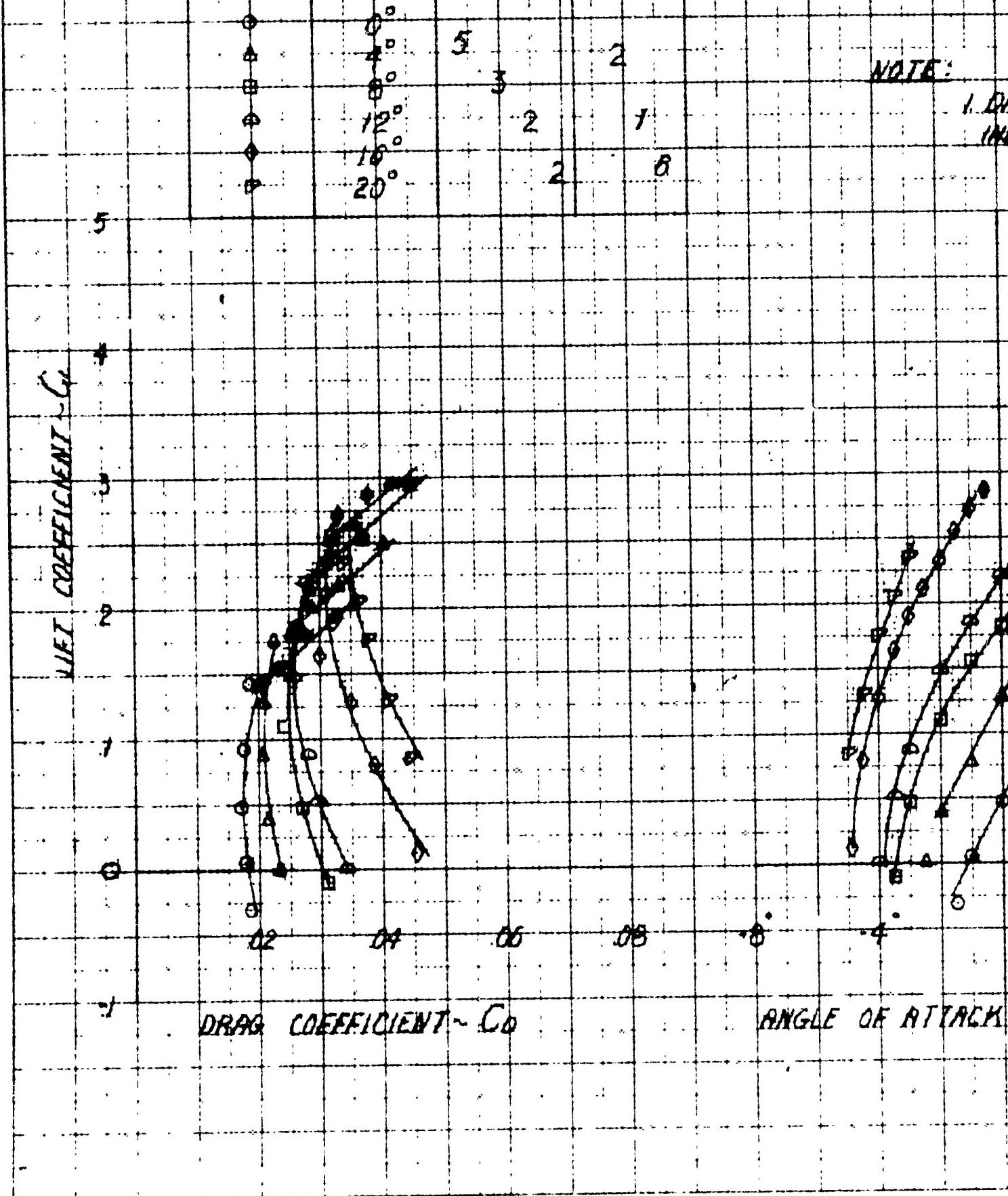
R/C = 1.00 V = 63 KTS

D SYMBOLS

VENTED FLOW.



SYMBOLS FLAP SET FRAUDULENT CAN NO

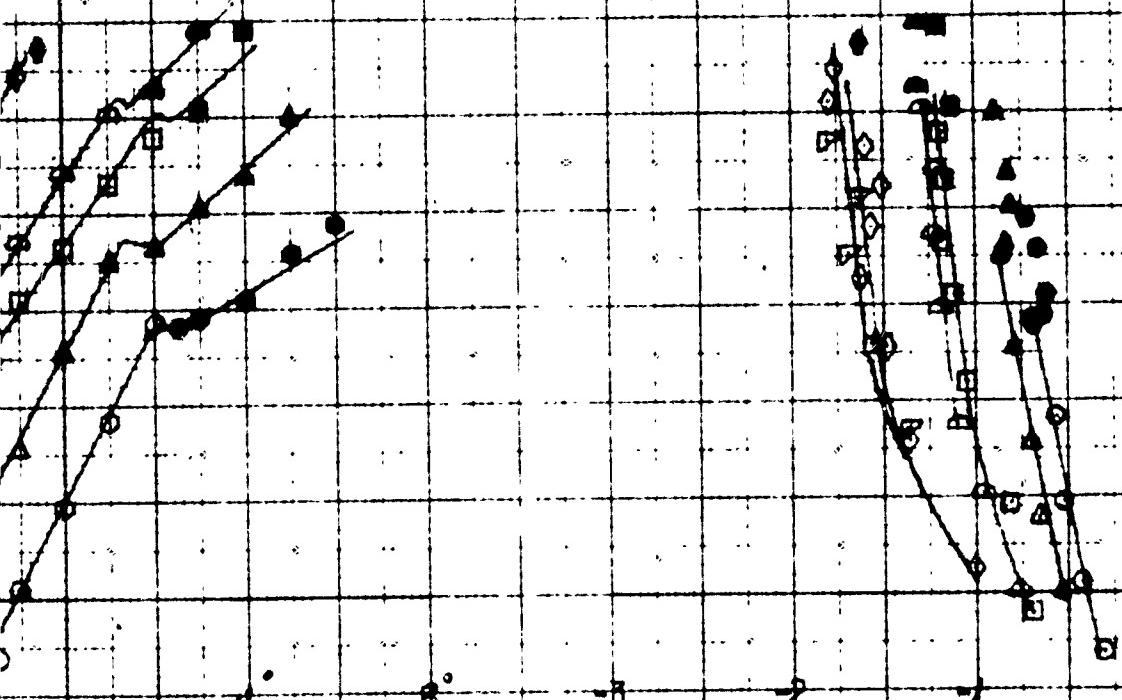


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WHIRLING TANK TEST NO 44
BU SHIPS FOIL NO 15
M.A.C. = 152 $S = 8.00 \text{ m}^2$

$d_L = 1.00$ $V = 70 \text{ KTS.}$

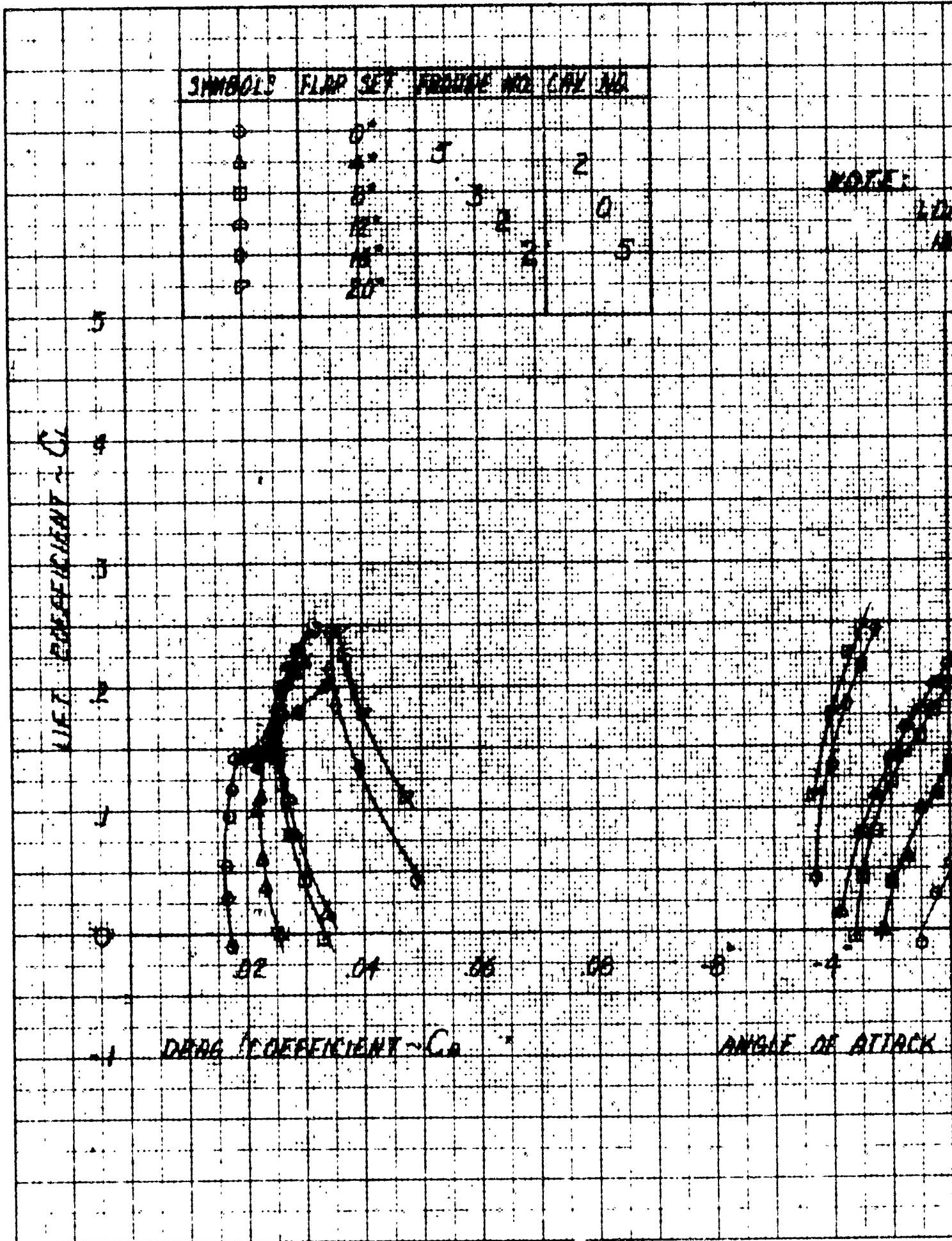
DARKENED SYMBOLS
INDICATE HEATED FLOW.



9CM ~ α - DEGREES

PITCHING MOMENT COEFFICIENT

C_m



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WHIRLING TANK TEST NO 44
BU SHIPS FOIL NO. 15
MAC = .152 FT $S = 0.00 \text{ IN}^2$
 $d/c = 1.00$ V. BOATS

DARKENED SYMBOLS
INDICATE WENTED FLOW.

